Geotechnical Investigation

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Proposed Residential Development
1770 Heatherington Road, Ottawa, ON
City of Ottawa SOA 30820-92500-SO1 Category 5A and 5B

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Introduction

EXP Services Inc. (EXP) is pleased to present the results of the geotechnical investigation completed for the proposed residential subdivision development to be located at 1770 Heatherington Road, in Ottawa, Ontario (Figure 1). Terms and conditions of this assignment were outlined in EXP's two (2) proposals dated April 18,2023 and March 1,2024 and is under EXP's standing offer agreement with the City of Ottawa SOA 30820-92500-S01 Category 5A and 5B. Authorization to proceed with this work was provided by City of Ottawa PO Number PO 0451055165.

It is noted that EXP completed Phase One and Two Environmental Site Assessments (ESAs), a Site-Specific Risk Assessment (SSRA) and a Soil Characterization of the two (2) soil berms on site under separate assignments for this project with the City of Ottawa.

Proposed Development

The site consists of a 2.7-hectare former City of Ottawa works yard that is currently vacant. It is understood that the site was formerly occupied by structures including office trailers, quonset huts, an above ground (liquid) calcium chloride storage tank, salt storage facilities, a maintenance garage and a storage shed. The property was also used as a snow dump site. These former structures have been removed from the site. It is not known if below grade floor slabs, foundation walls and foundations of the former buildings/structures and former underground services were also excavated and removed from the site.

The draft functional grading plan, Drawing No. GP-1, dated November 15, 2023 (Revision No. 1), prepared by Stantec Consulting Ltd. (Stantec) indicates the site is divided into fifteen (15) building blocks, namely Blocks 1 to 15. The residential development will consist of two low-rise apartment buildings (2 to 3-storeys) at Blocks 1 and 14 and townhouse-type buildings at the remaining blocks. An outdoor park is proposed at Block 16. The buildings will all have one (1) basement level. The site will be serviced by municipal services, there will be outdoor paved parking lots and a horizontal U-shaped access road within the site leading at two (2) locations to Heatherington Road. Stantec indicated that the proposed elevation of the underside of the footing (USF) for the buildings will be 1.8 m below the design elevation of the proposed centreline of the U-shaped access road and that the site grade raise in the blocks will be 1.0 m above the proposed design elevations of the centreline of the new U-shaped access road.

The draft functional site servicing plan, Drawing No. SSP-1, dated November 15, 2023 (Revision No.1) and prepared by Stantec indicates the pipe obvert for 200 mm to 675 mm diameter underground service pipes ranges from Elevation 85.32 m to Elevation 84.27 m, approximately 3.0 m to 4.0 m below existing grade.

Borehole Fieldwork Program

The fieldwork for this geotechnical investigation was undertaken in two (2) phases and consists of fourteen (14) boreholes and six (6) static cone penetration tests (piezocone penetration tests, CPTs). The first phase was undertaken from November 21 to December 12,2023 and consists of nine (9) boreholes (Borehole Nos. 23-1 to 23-9) advanced to auger refusal and termination depths ranging from 5.6 m to 9.9 m below existing grade. The second phase was undertaken from March 24 to 26,2024 and consists of five (5) boreholes (Borehole Nos. 24-10 and 24-12 to 24-15) and six (6) piezocone penetration tests (CPTu 1, CPTu 2, SCPTu 3, CPTu 4, SCPTu 5 and CPT 6). Borehole No. 24-11 was not drilled. The boreholes extended to auger and casing refusal depths of 5.9 m to 6.9 m below existing grade. The piezocone penetration tests (CPTs) extended to 4.5 m to 6.2 m below existing grade. The borehole and cone penetration test fieldwork was supervised on a full-time basis.

Subsurface Conditions

The information from the boreholes indicates the subsurface conditions at the site consist of surficial topsoil and reclaimed asphalt pavement (RAP) underlain by fill that extends to depths of 0.3 to 3.2 m (Elevation 87.2 m to Elevation 84.3 m) further underlain by firm to very stiff silty clay to depths ranging from 2.2 m to 4.5 m (Elevation 85.7 m to Elevation 82.7 m), very loose to very dense glacial till that extends to depths of 5.5 m to 6.2 m (Elevation 82.3 m to Elevation 80.3 m) followed by shale bedrock contacted at 5.5 m to 6.2 m depths (Elevation 82.3 m to Elevation 80.3 m). It is noteworthy to mention that 75 mm to 200 mm thick buried organic clayey silt layers are present in some boreholes. Based on the recent April 17,2024 set of measurements, the groundwater level ranges from 1.1 m to 2.7 m depths (Elevation 86.4 m to Elevation 84.6 m).

Geotechnical Engineering Comments and Recommendations

Liquefaction analysis was conducted using the data collected from the boreholes and the piezocone penetration tests (CPTs). The analysis indicates the silty clay above the glacial till is not liquefiable during a seismic event. The analysis indicates the very loose to compact zone of the glacial till is liquefiable during a seismic event with an average factor of safety of less than 1.0. The glacial till is liquefiable in in Blocks 3,8,10,12,13 and 15. The glacial till is not liquefiable in Blocks 1,2,6 and 14. Post-liquefaction settlements were calculated to range from 56 mm to 168 mm. The approximate area of the liquefiable glacial till on site is shown in Figure 3 of the attached report. It is not known if the subsurface soils in Blocks 4,5,7 and 9 are liquefiable. However, since these blocks are located between blocks where the glacial till has been determined to be liquefiable, Blocks 4,5,7 and 9 along with Block 6 are included within the approximate area of the liquefiable glacial till shown in Figure 3.

Ground improvement at the site will be required to address the presence of the liquefiable soils to ensure performance of the buildings and basement floor slabs (lowest slabs) during a seismic event. A local specialized contractor was contacted and confirmed that the site can be improved to address the liquefiable soil and to possibly improve the bearing pressures recommended for the footings to support the proposed buildings. The contractor indicated that controlled modulus columns (CMCs) is the most appropriate method to improve the ground at the site.

Since liquefiable soils have been established on site, Table 4.1.8.4.A of the 2012 OBC (as amended January 2022) indicates that for liquefiable soils, the site classification for seismic response is **Class F**. However, for the determination of the site classification for seismic response, the OBC permits that the presence of liquefiable soils can be ignored, provided the proposed buildings will be designed for a fundamental period of vibration equal to or less than 0.5 seconds.

For the case where the liquefiable soils are ignored by designing the proposed buildings for a fundamental period of vibration equal to or less than 0.5 seconds or are addressed by ground improvement, data from SCPTu 3 and SCPTu 5 was used to determine the site classification for seismic response. SCPTu 3 and SCPTu 5 measured the shear wave velocity within the silty clay and glacial till. The average shear wave velocity was determined to be 125 m/s. Based on an assumed shear wave velocity for the underlying shale bedrock of 1000 m/s from Table 4.1.8.4.A of the 2012 Ontario Building Code (as amended January 1,2022), the weighted average of the shear wave velocity for a 30 m depth is 1164 m/s. Based on Table 4.1.8.4.A of the 2012 OBC (as amended January 2022), for a shear wave velocity of 1164 m/s and that the underside of the footings will be greater than 3.0 m from the bedrock, the classification of the site for seismic response is **Class C**.

It is EXP's opinion that consideration should be strongly given to improving the ground at the site to address the liquefaction issue to ensure the long-term satisfactory performance of the proposed buildings and basement floor slabs (lowest floor slab) during a seismic event, since the calculated post-liquefaction settlements may render the proposed buildings non-operational. The ground improvement may also increase or improve the SLS and factored ULS values recommended in this report for the proposed site grade raise.

Based on information and drawings from Stantec, the grade raise at the blocks and along the subdivision access road is anticipated to range from approximately 0.5 m to 2.5 m. Along the proposed subdivision road, there are some cut areas. The proposed site grade raise indicated for each block and along the proposed subdivision access road are considered acceptable from a geotechnical perspective. It is recommended that should the magnitude of the site grade raise change and be different than indicated in this report for the blocks and access road, EXP should be contacted to review the acceptability of the site grade raise.

For the blocks located within the approximate area of the liquefiable soil shown in Figure 3 of the attached report, if the post-liquefaction settlements of 56 mm to 168 mm are acceptable and can be tolerated by the building foundations and slab-on-grade, the proposed buildings may be supported by spread and strip footings designed to bear on the native silty clay, glacial till or engineered fill (constructed on the native soils) and the lowest floor slab (basement slab) may be designed as a slab-on-grade supported by the native soils. The footings founded at the underside of footing elevation (USF) determined from the Stantec drawing and indicated in Table IX may be designed for the bearing pressure at serviceability limit state (SLS) and factored geotechnical resistance at ultimate limit state (ULS) values indicated in Table IX of the attached report.

If the post-liquefaction settlements for the blocks located within the approximate area of the liquefiable soil shown in Figure 3 of the attached report are not acceptable and cannot be tolerated by the building foundations and slab-on-grade, ground improvement will be required. Once ground improvement has been completed, the proposed buildings may be supported by spread and strip footings founded on the improved soil and the lowest floor slab (basement slab) may be designed as a slab-on-grade supported by the improved soil. The footings founded at the USF indicated in Table IX may be designed for the SLS and

factored ULS values recommended in Table IX of the attached report. The total and differential settlements of the footings founded on the improved soil will be within normally tolerated limits of 25 mm total settlement and 19 mm differential settlement. It is possible that the SLS and factored ULS values along with the site grade raise can be increased as a result of the ground improvement.

For the two (2) proposed low-rise apartment buildings (2 to 3-storeys) to be located at Blocks 1 and 14 in a non-liquefiable area, the recommended SLS and factored ULS values for footings may not be sufficient to support the proposed buildings. In this case, the proposed buildings may be supported by pile foundations driven to practical refusal into the underlying shale bedrock and designed in end bearing. Caisson foundations are considered to be problematic due to the high groundwater level in combination with the very loose to compact zone of the silty sand glacial till below the groundwater level. Also, it is anticipated that with caissons, costs will be incurred from the removal and disposal of the soil spoil generated from each caisson. As an alternative to piles, even though Blocks 1 and 14 do not have liquefiable soils, if it is decided to use ground improvement at the other blocks (with liquefiable soils), ground improvement may also be considered for Blocks 1 and 14 to improve the SLS and factored ULS values sufficiently so that the proposed apartment buildings may be supported by footings founded on the improved soil.

The floor slab for the proposed buildings may be designed and constructed as a slab-on-grade placed on a 200 mm thick, 19 mm sized clear stone bed placed on a minimum 300 mm thick engineered fill pad set on the approved native subgrade constructed in accordance with Section 10.1 of the attached report. The clear stone will minimize the capillary rise of moisture from the sub-soil to the floor slab. Alternatively, the clear stone layer may be replaced with a 200 mm thick bed of OPSS Granular A overlain by a vapour barrier. Adequate saw cuts should be provided in the floor slabs to control cracking.

The proposed buildings will require a perimeter drainage system. The need for underfloor drainage system for the proposed buildings can be determined once the final design elevation of the basement floor is available.

The excavations may be undertaken by conventional heavy equipment capable of removing possible debris within the fill and cobbles and boulders within the glacial till.

Open cut excavations within the soils above the groundwater level are anticipated to be relatively straight forward. If ground improvement is selected to be used on this site, the excavation and dewatering comments and recommendations provided in this report may need to be updated.

All excavations must be undertaken in accordance with the Occupational Health and Safety Act (OHSA), Ontario Reg. 213/91. Based on the definitions provided in OHSA, the subsurface soils on site are considered to be Type 3 and as such must be cut back at 1H:1V from the bottom of the excavation. Within zones of seepage, the excavation side slopes are expected to slough and eventually stabilize at 2H:1V to 3H:1V from the bottom of the excavation. For excavations above the groundwater level or properly dewatered (refer to paragraph below), the installation of the municipal underground services may be undertaken within the confines of a prefabricated support system (trench box) designed and installed in accordance with OHSA.

Open cut excavations that extend into the silty sand to sandy silt glacial till below the groundwater level are anticipated to be more problematic and will require the lowering of the groundwater level prior to the start of excavation. It is anticipated that the base of the excavation in the silty sand to sandy silt glacial till and below the groundwater level may be susceptible to basal instability or base type failure in the form of piping or heave. To minimize the occurrence of base type failure, it is recommended that the groundwater level should be lowered by at least 1.0 m below the bottom of the excavation prior to the start of excavation. This may be achieved by installing deep sumps and pumping with high-capacity pumps. The dewatering contractor should review the subsurface conditions at the site and select the most appropriate method to lower the groundwater level.

Seepage of the surface and subsurface water into the excavations is anticipated. However, it should be possible to remove groundwater entering into the excavation by pumping from sumps. In areas of high infiltration or in areas where more permeable soil layers may exist, a higher seepage rate should be anticipated and will require high-capacity pumps to keep the excavation dry (possibly required to operate 24 hours a day, seven (7) days a week).

The pipe bedding for the installation of underground services including material specifications, thickness of cover material and compaction requirements should conform to City of Ottawa specifications, drawings and special provisions. The bedding and cover material should be compacted to a minimum of 95 percent standard Proctor maximum dry density (SPMDD).

It is anticipated that the majority of the material required for backfilling purposes in the interior and exterior of the proposed buildings and in the underground service trenches will need to be imported and should preferably conform to the material specifications indicated in the attached geotechnical report.

The above and other related considerations are discussed in greater detail in the main body of the attached geotechnical report.

1. Introduction

EXP Services Inc. (EXP) is pleased to present the results of the geotechnical investigation completed for the proposed residential subdivision development to be located at 1770 Heatherington Road, in Ottawa, Ontario (Figure 1). Terms and conditions of this assignment were outlined in EXP's two (2) proposals dated April 18,2023 and March 1,2024 and is under EXP's standing offer agreement with the City of Ottawa SOA 30820-92500-S01 Category 5A and 5B. Authorization to proceed with this work was provided by City of Ottawa PO Number PO 0451055165.

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The site consists of a 2.7-hectare former City of Ottawa works yard that is currently vacant. It is understood that the site was formerly occupied by structures including office trailers, quonset huts, an above ground (liquid) calcium chloride storage tank, salt storage facilities, a maintenance garage and storage shed. The property was also used as a snow dump site. These former structures have been removed from the site. It is not known if below grade floor slabs, foundation walls and foundations of the former buildings/structures and former underground services were also excavated and removed from the site.

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The geotechnical investigation was undertaken to:

a) Establish the subsurface soil and groundwater conditions at fourteen (14) boreholes and six (6) static cone penetration tests (piezocone penetration tests) located on the site,

b) Classify the site for seismic site response in accordance with the requirements of the 2012 Ontario Building Code (as amended January 1,2022) and assess the potential for liquefaction of the subsurface soils during a seismic event,

c) Comment on grade-raise restrictions and provide site grading requirements,

d) Make recommendations regarding the most suitable type of foundations, founding depth and bearing pressure at serviceability limit state (SLS) and factored geotechnical resistance at ultimate limit state (ULS) of the founding strata and comment on the anticipated total and differential settlements of the recommended foundation type,

e) Provide comment regarding slab-on-grade construction and the requirement for perimeter and underfloor drainage systems,

f) Comment on excavation conditions and de-watering requirements during construction,

g) Provide pipe bedding requirements for underground services,

h) Discuss backfilling requirements and suitability of on-site soils for backfilling purposes,

i) Recommend pavement structure thicknesses for access road and parking lots,

j) Comment on the corrosion potential of subsurface soils buried concrete and steel structures/members; and

k) Provide comment on tree planting restrictions.

The comments and recommendations given in this report are based on the assumption that the above-described design concepts will proceed into construction. If changes are made either in the design phase or during construction, this office must be retained to review these modifications. The result of this review may be a modification of our recommendations, or it may require additional field or laboratory work to check whether the changes are acceptable from a geotechnical viewpoint.

2. Site Description

The site for the proposed residential development consists of a former City of Ottawa works yard that is partially surrounded by a chain link fence. The site is U shaped and is currently vacant, however, remnants of materials are stored on the site and include three (3) sand stockpiles, concrete, wooden pallets and lumber. The site is also occupied by two (2) soil berms located in the southwest and south portions of the site.

The ground surface of the site is covered with asphaltic concrete and fill. Tall shrubs and medium sized trees exist along the south portion of the site in addition to a gravel access road.

The site is bound to the north and the south by residential developments, to the west by a Drive Ontario testing facility and to the east by Heatherington Road. The Boys and Girls Club of Ottawa is located east of the site.

Based on the ground surface elevations at the boreholes, Elevation 88.01 m to Elevation 86.49 m, the ground surface gradually slopes down in an east and south direction.

Photographs of the site are shown in Appendix A.

3. Site Geology

3.1 Surficial Geology Map

The surficial geology was reviewed via the Google Earth applications published by the Ontario Ministry of Energy, Northern Development and Mines available via www.mndm.gov.on.ca/en/mines-and-minerals/applications/ogsearth/surficial-geology and was last modified on May 23, 2017. The map indicates the site is underlain by fine-textured glaciomarine deposits consisting of silt and clay with minor sand and gravel. Older alluvial deposits are present to the southeast of the site. The surficial deposits are shown in Image 1 below.

Fine-textured glaciomarine deposits consisting of silt and clay with minor sand and gravel

Older alluvial deposits: clay, silt, sand, gravel, may contain organic remains

Image 1 – Surficial Geology

3.2 Bedrock Geology Map

The surficial geology was reviewed via the Google Earth applications published by the Ontario Ministry of Energy, Northern Development and Mines available via http://www.geologyontario.mndm.gov.on.ca/mines/data/google/MRD219/geology/doc.kml and publish in 2007. The map indicates the bedrock at the site consists of shale and limestone of the Carlsbad formation. The shale of the Carlsbad formation is an expansive type of shale. The bedrock geology is show in Image 2 below.

Carlsbad Formation: Shale and limestone

Image 2 – Bedrock Geology

4. Available Information

EXP (formerly Trow Associates Inc.) completed a geotechnical investigation at the site in 2008 and the results of the geotechnical investigation are provided in the report titled, *Preliminary Geotechnical Investigation, Proposed Residential Development, 1770 Heatherington Road, City of Ottawa, Ontario* dated October 17,2008 (EXP Project No. OTGE00018293-JB). Borehole (BH)/Monitoring Well (MW) Nos. 08-10 to 08-17 from the 2008 geotechnical investigation are located on the current site and their locations are shown on the Test Hole Location Plan, Figure 2. The 2008 borehole logs are provided in Appendix B.

The geodetic ground surface elevations for some of the 2008 borehole/monitoring well locations were interpolated from the spot elevations provided on the 2023 draft functional grading plan by Stantec. Therefore, the ground surface elevations at these borehole locations are considered approximate.

5. Procedure

The fieldwork for this geotechnical investigation was undertaken in two (2) phases and consists of fourteen (14) boreholes and six (6) static cone penetration tests (piezocone penetration tests, CPTs). The first phase was undertaken from November 21 to December 12,2023 and consists of nine (9) boreholes (Borehole Nos. 23-1 to 23-9) advanced to auger refusal and termination depths ranging from 5.6 m to 9.9 m below existing grade. The second phase was undertaken from March 24 to 26,2024 and consists of five (5) boreholes (Borehole Nos. 24-10 and 24-12 to 24-15) and six (6) piezocone penetration tests (CPTu 1, CPTu 2, SCPTu 3, CPTu 4, SCPTu 5 and CPT 6). Borehole No. 24-11 was not drilled. The boreholes extended to auger and casing refusal depths of 5.9 m to 6.9 m below existing grade. The piezocone penetration tests (CPTs) extended to 4.5 m to 6.2 m below existing grade. The borehole and cone penetration test fieldwork was supervised on a full-time basis by EXP.

The locations and geodetic elevations of the boreholes and piezocone penetration tests were established by EXP and are shown on the test hole location plan, Figure 2. The ground surface elevation of Borehole No. 23-5 was interpolated from the spot elevation provided on the functional grading plan prepared by Stantec dated November 15,2023 (Revision No. 1). Therefore, the ground surface elevation for Borehole No. 23-5 should be considered approximate.

The boreholes were drilled using a CME-45 track-mounted drill rig equipped with continuous flight hollow-stem auger equipment and rock coring capabilities. Below the augered depth of 1.5 m, the 2024 boreholes (Borehole Nos. 24-10 and 24-12 to 24-15) were advanced to casing refusal depths using casing and wash-boring technique and maintaining a head (column) of water in the casing. Standard penetration tests (SPTs) were performed in all the boreholes at 0.75 m to 1.5 m depth intervals and the soil samples retrieved by the split-spoon sampler. The undrained shear strength of the clayey soil was measured at selected depths by conducting penetrometer and in-situ vane tests. A relatively undisturbed thin-walled tube sample (Shelby tube) of the silty clay was collected at a selected depth in one (1) borehole. The bedrock was cored in three (3) boreholes using the N-size core barrel and conventional rock coring techniques. A field record of wash water return, colour of wash water and any sudden drops of the core barrel were kept during rock coring operations.

The subsurface soil conditions in each borehole were logged with each soil sample placed in labelled plastic bags. Similarly, the rock cores were visually examined, placed in core boxes, identified, and logged.

Nineteen (19 mm) diameter standpipes, thirty-two (32) mm diameter and fifty (50) mm diameter monitoring wells were installed in selected boreholes for long-term monitoring of the groundwater table and for groundwater sampling as part of the Phase Two ESA. The standpipes and monitoring wells were installed in accordance with EXP standard practice, and the installation configuration is documented on the respective borehole log. The boreholes were backfilled upon completion of drilling and installation of the standpipes and monitoring wells.

Static cone penetration tests (piezocone penetration tests, CPTs) were conducted at six (6) locations on the site. The piezocone penetration tests, CPTu 1, CPTu 2, CPTu 4 and CPTu 6, also measured the pore pressure. The piezocone penetration tests, SCPTu 3 and SCPTu 5 measured the shear wave velocity (seismic) in addition to pore pressure. The CPTs extended from the augered depths of 1.5 m and 1.6 m, locally a 3.0 m depth in CPTu 1, to termination depths of 4.5 m to 6.2 m below existing grade.

On completion of the borehole fieldwork, the soil samples and rock cores were transported to the EXP laboratory in Ottawa where they were examined by a geotechnical engineer and borehole logs prepared. The soils are classified by their main constituents in accordance with the Unified Soil Classification System (USCS) using the soil group name and symbol and by the modified Burmister soil classification method for the classification of the minor constituents of the soil using adjectives and modifiers such as trace and some (2006 Fourth Edition of the Canadian Foundation Engineering Manual (CFEM)).

The rock cores were visually examined by the geotechnical engineer and logged in accordance with Section 3.2 of the 2006 Canadian Foundation Engineering Manual (CFEM) Fourth Edition. Photographs were taken of the bedrock cores.

The laboratory testing program for the soil samples and rock core sections is summarized in Table I.

Table I: Summary of Laboratory Testing Program	
Type of Test	Number of Tests Completed
Soil Samples	
Moisture Content Determination	105
Unit Weight Determination	6
Grain Size Analysis	17
Atterberg Limit Determination	17
Corrosion Analysis (pH, sulphate, chloride and resistivity)	3
Bedrock Core Sections	
Unconfined Compressive Strength and Unit Weight Determination	3

6. Subsurface Conditions and Groundwater Levels

A detailed description of the subsurface conditions encountered in the boreholes is given on the attached Borehole Logs, Figures 4 to 17. The results of the piezocone penetration tests (CPTs) are shown in Appendix C.

The borehole logs and related information depict subsurface conditions only at the specific locations and at the times indicated. Subsurface conditions and water levels at other locations may differ from conditions at the locations where sampling was conducted. The passage of time also may result in changes in the conditions interpreted to exist at the locations where sampling was conducted.

Boreholes were drilled to provide representation of subsurface conditions as part of a geotechnical exploration program and are not intended to provide evidence of potential environmental conditions. Reference should be made to the EXP Phase One and Two Environmental Site Assessments (ESAs), the Site-Specific Risk Assessment (SSRA) and the Soil Characterization of the two (2) soil berms on site for potential environmental concerns for the subsurface conditions and soil berms at the site.

It should be noted that the soil boundaries indicated on the borehole logs are inferred from observations during drilling operations. These boundaries are intended to reflect approximate transition zones for the purpose of geotechnical design and should not be interpreted as exact planes of geological change. The “Notes on Sample Descriptions” preceding the borehole logs form an integral part of this report and should be read in conjunction with this report.

A review of the borehole logs indicates the following subsurface soil and bedrock conditions with depth and groundwater level measurements.

6.1 Topsoil

A 50 mm to 300 mm thick surficial topsoil layer was contacted in Borehole No. 23-7, 24-10, 24-12 and 24-15.

6.2 Reclaimed Asphalt Pavement (RAP)

A 75 mm thick surficial layer of reclaimed asphaltic pavement (RAP) was encountered in Borehole No. 23-1.

6.3 Fill

Fill was contacted beneath the surficial topsoil and RAP layer in Borehole Nos. 23-1, 24-10, 24-12 and 24-15, and surficially in the remaining boreholes. The fill extends to depths of 0.3 m to 3.2 m (Elevation 87.2 m to Elevation 84.3 m). The 3.2 m deep fill was contacted in Borehole No. 23-5. The fill ranges from crushed gravel to silty sand with gravel to silty sand to silty clay and contains topsoil and possible cobbles and boulders. The fill is in a very loose to very dense state. The moisture content of the fill ranges from 10 percent to 36 percent.

A mixture of silty sand fill and RAP was contacted beneath the surficial topsoil layer in Borehole No. 24-10 and extends to a 0.8 m depth (Elevation 86.9 m). Based on standard penetration test (SPT) N-value, the fill mixture is in a compact state. The moisture content of the fill mixture is 13 percent.

6.4 Buried Organic Clayey Silt

A buried organic clayey silt layer was encountered below the fill in Borehole Nos. 23-2, 23-7 to 23-9 and 24-10. The thickness of the organic clayey silt layer ranges from 75 mm to 200 mm.

6.5 Silty Clay

Silty clay was contacted below the fill and the buried organic clayey silt layer in all of the boreholes, with the exception of Borehole No. 23-5. The silty clay extends to depths ranging from 2.2 m to 4.5 m depths (Elevation 85.7 m to Elevation 82.7 m). The silty clay consists of an upper desiccated/weathered brown crust underlain by a weaker un-desiccated/unweathered grey silty clay. The weaker grey silty clay is not present beneath the brown silty clay in Borehole No. 23-2, 23-3 and 23-6.

6.5.1 Upper Desiccated Brown Silty Clay Crust

The upper brown desiccated silty clay crust extends to depths of 2.1 m to 2.8 m (Elevation 85.4 m to Elevation 84.3 m). The brown silty clay contains sand seams. The undrained shear strength of the crust is 90 kPa to 150 kPa indicating the brown silty clay has a stiff to very stiff consistency. The natural moisture content and unit weight of the silty clay crust is 11 percent to 76 percent and 16.5 kN/m^3 to 18.5 kN/m^3 respectively.

Results from the grain-size analysis and Atterberg limit determination conducted on two (2) samples of the upper brown silty clay are summarized in Table II. The grain-size distribution curves are shown in Figures 18 and 19.

Table II: Summary of Results from Grain-Size Analysis and Atterberg Limit Determination – Brown Silty Clay Samples

Borehole No. (BH) Sample No. (SS)	Depth (m)	Grain-Size Analysis (%) and Atterberg Limits (%)								
		Gravel	Sand	Silt	Clay	Moisture Content	Liquid Limit	Plastic Limit	Plasticity Index	Soil Classification
BH23-3: SS3	1.5-2.1	0	7	30	63	41	50	23	27	Silty Clay of Medium to High Plasticity (CI-CH) - trace sand
BH23-9: SS2	0.8-1.4	0	17	21	62	35	52	22	30	Silty Clay of High Plasticity (CH) – some sand

Based on a review of the results of the grain-size analysis and Atterberg limits, the soil may be classified as a silty clay of medium to high (CI-CH) with trace to some sand.

6.5.2 Grey Silty Clay

The brown silty clay crust in Borehole Nos. 23-1, 23-4, 23-7 to 23-9, 24-10 and 24-12 to 24-15 is underlain by a grey silty clay. The grey silty clay extends to depths ranging from 3.3 m to 4.5 m (Elevation 84.0 m to Elevation 82.7 m). The undrained shear strength of the grey silty clay is 29 kPa to 100 kPa indicating the silty clay has a firm to stiff/very stiff consistency. The firm zone of the silty clay exhibiting a low undrained shear strength value of 29 kPa is locally present from 3.1 m to 4.1 m depth (Elevation 84.4 m to Elevation 83.4 m) in Borehole No. 23-1 and at a 2.9 m depth (Elevation 84.3 m) in Borehole No. 24-15. The natural moisture content of the grey silty clay is 53 percent to 75 percent.

Results from the grain-size analysis and Atterberg limit determination conducted on eight (8) samples of the lower grey silty clay are summarized in Table III. The grain-size distribution curves are shown in Figures 20 to 27.

Table III: Summary of Results from Grain-Size Analysis and Atterberg Limit Determination – Grey Silty Clay Samples										
Borehole No. (BH) Sample No. (SS)	Depth (m)	Grain-Size Analysis (%) and Atterberg Limits (%)								
		Gravel	Sand	Silt	Clay	Moisture Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	Soil Classification
BH23-1: SS4	3.4-3.7	0	6	32	62	65	49	21	28	Silty Clay of Medium Plasticity (CI) - trace sand
BH23-7-SS4	3.0-3.6	0	8	34	58	55	51	19	32	Silty Clay of High Plasticity (CH) - trace sand
BH 24-10 – SS4	2.3-2.9	4	2	34	60	62	53	21	32	Silty Clay of High Plasticity (CH) – trace gravel and sand
BH 24-12: SS5	3.0-3.5	0	11	49	50	53	47	19	28	Silty Clay of Medium Plasticity (CI) – some sand
BH 24-13: SS5	3.0-3.5	0	2	40	58	75	52	22	30	Silty Clay of High Plasticity (CH) – trace sand
BH 24-14: SS5	3.0-3.5	0	7	40	53	55	42	16	26	Silty Clay of Medium Plasticity (CI) – trace sand
BH 24-15: SS5	3.0-3.5	1	3	41	55	54	50	21	29	Silty Clay of Medium to High Plasticity (CI-CH) – trace gravel and sand
BH 24-15: SS6	3.8-4.3	5	18	40	37	61	36	16	20	Silty Clay of Medium Plasticity (CI) – some sand, trace gravel

Based on a review of the results of the grain-size analysis and Atterberg limits, the soil may be classified as a silty clay of medium to high plasticity (CI-CH) with trace gravel and trace to some sand.

A consolidation test was conducted on one (1) sample of the grey silty clay. The soil parameters derived from the consolidation test results are summarized in Table IV and the consolidation test result report is shown in Appendix D.

Table IV: Consolidation Test Results – Grey Silty Clay Sample								
Borehole No.	Sample No. (Sample Depth, m)	Natural Unit Weight (kN/m³)	σ_p'	σ_{vo}'	C_c	C_r	e_o	OCR
BH23-1	ST1 (3.0 - 3.6)	16.3	110	45	0.576	0.035	1.623	2.4

NOTES:

σ_p'	- Apparent pre-consolidation pressure (kPa)	σ_{vo}'	- Calculated existing vertical effective pressure (kPa)
C_c	- Compression index	C_r	- Recompression index
e_o	- Initial void ratio	OCR	- Over consolidation ratio

6.6 Shaley Glacial Till

Beneath the fill in Borehole No. 23-5 and the silty clay in the remaining boreholes, shaley glacial till was contacted and extends to depths of 5.5 m to 6.2 m (Elevation 82.3 m to Elevation 80.3 m). The glacial till consists primarily of a silty sand matrix with a localized sandy silt matrix. Locally, in Borehole Nos. 23-7 and 23-8, the glacial till consists of a silty clay matrix. The glacial till contains varying percentages of fine gravel i(n the form of shale fragments), sand, silt and clay. The glacial till contains sand and clay seams. The glacial till may also contain possible cobbles and boulders. Based on the SPT N-values of 0 to 96, the glacial till is in a very loose to very dense state. Based on the SPT-N-values of the silty clay portion of the glacial till in Borehole Nos. 23-7 and 23-8 of 0 to 5, the silty clay portion of the glacial till has a very soft to firm consistency. In some boreholes, the SPT N-value is high for low sampler penetration, such as 50 for 125 mm of sampler penetration. This may be a result of the sampler making contact with a possible cobble, boulder or concentrated zone of seams of shale fragments. The natural moisture content of the glacial till ranges from 7 percent to 39 percent.

The results from the grain-size analysis and Atterberg limit determination conducted on seven (7) samples of the glacial till are summarized in Table V. The grain-size distribution curve is shown in Figures 28 to 34.

Table V: Summary of Results from Grain-Size Analysis and Atterberg Limit Determination – Glacial Till Samples										
Borehole No. (BH): Sample No. (SS)	Depth (m)	Grain-Size Analysis (%) and Atterberg Limits (%)								
		Gravel	Sand	Silt	Clay	Moisture Content	Liquid Limit	Plastic Limit	Plasticity Index	Soil Classification
BH 23-2: SS4	2.3-2.9	6	46	29	19	39	29	16	13	Silty Sand (SM) – some clay of low plasticity, trace gravel
BH 23-3: SS5	3.8-4.4	9	42	32	17	13	19	15	4	Silty Sand (SM) – some clay of low plasticity, trace gravel
BH 23-4: SS5	4.6-5.2	14	38	33	15	14	22	11	11	Silty Sand (SM) – some gravel and clay of low plasticity
BH 23-7: SS5	4.6-5.2	10	35	36	19	17	24	12	12	Silty Clay of Low Plasticity (CL) – sandy, trace gravel
BH 23-9: SS5	4.6-5.2	22	46	27	5	9	-	-	Non-Plastic	Silty Sand (SM) – gravelly, trace clay
BH 24-12: SS7	4.6-5.2	9	47	29	15	18	20	14	6	Silty Sand (SM) – some clay of low plasticity, trace gravel
BH 24-13: SS7	4.6-5.2	15	37	34	14	14	21	14	7	Silty Sand (SM) – some gravel and clay of low plasticity

Based on a review of the test results of the grain-size analysis and Atterberg limits, the glacial till may be classified as a silty sand (SM) with trace to some gravel/gravelly and trace to some clay to a silty clay of low plasticity (CL) that is sandy with trace gravel. The glacial till may contain possible cobbles and boulders.

6.7 Highly Weathered (Soil Like) Shale Bedrock

Highly weathered shale bedrock (soil like) was encountered underlying the shaley glacial till in Borehole Nos. 23-1, 23-2 and 23-5 at 5.5 m to 6.2 m depths (Elevation 82.3 m to Elevation 81.3 m). It was possible to auger 300 mm to 700 mm into the highly weathered shale bedrock.

6.8 Inferred and Actual Bedrock

Auger and casing refusal was met at 5.6 m to 6.9 m depths (Elevation 81.6 m to Elevation 80.0 m) in Borehole Nos. 23-3, 23-4, 23-7, 23-8, 24-10 and 24-12 to 24-15 on inferred cobbles, boulders or bedrock. The presence of the bedrock was proven by rock coring technique in Borehole Nos. 23-1 (below the augered weathered zone), 23-6 and 23-9. The bedrock was encountered at a 6.2 m depth (Elevation 81.3 m to Elevation 80.3 m) in these boreholes. Photographs of the bedrock cores are shown in Appendix E.

The bedrock is black shale of the Carlsbad formation. A review of the borehole logs indicates that the total core recovery (TCR) ranges between 89 percent and 100 percent and the rock quality designation (RQD) ranges between 33 percent and 83 percent indicating the bedrock is of a fair to good quality. In Borehole No. 23-1, the upper 900 mm of the shale bedrock from 6.7 m to 7.6 m depths (Elevation 80.8 m to Elevation 79.9 m) has an RQD value of 0 percent indicating a very poor quality of rock.

Unit weight determination and unconfined compressive strength tests were conducted on three (3) rock core sections. The test results are summarized in Table VI.

Table VI: Summary of Unconfined Compressive Strength Test Results – Bedrock Cores				
Borehole (BH) No.: Run No.	Depth (m)	Unit Weight (kN/m³)	Unconfined Compressive Strength (MPa)	Classification of Rock with respect to Strength
BH23-1: Run3	9.5-9.7	25.6	34.3	Medium Strong R3
BH23-6: Run1	7.0-7.2	25.8	21.3	Weak R2
BH23-9: Run2	7.5-7.7	26.2	41.5	Medium Strong R3

A review of the test results in Table VI indicates the strength of the rock may be classified as weak (R2) to medium strong (R3) in accordance with the Canadian Foundation Engineering Manual (CFEM), Fourth Edition, 2006.

6.9 Groundwater Level Measurements

A summary of the groundwater level measurements taken in the boreholes equipped with standpipes and monitoring wells on January 9 and April 17,2024 is shown in Table VII.

Table VII: Summary of Groundwater Level Measurements

Borehole No.	Ground Surface Elevation (m)	Date of Measurement (Elapsed Time in Days from Date of Installation)	Groundwater Depth Below Ground Surface (Elevation), m
BH 23-2	87.88	April 17,2024 (138 days)	1.7 (86.2)
BH23-2	87.88	January 9, 2024 (39 Days)	1.9 (86.0)
BH 23-3	87.60	April 17,2024 (146 days)	1.9 (85.7)
BH23-3	87.60	January 9, 2024 (47 Days)	1.8 (85.8)
BH 23-4	87.32	April 17,2024 (138 days)	2.7 (84.6)
BH23-4	87.32	January 9, 2024 (39 Days)	2.7 (84.6)
BH 23-8	87.15	April 17,2024 (146 days)	1.1 (86.1)
BH23-8	87.15	January 9, 2024 (49 Days)	1.3 (85.9)
BH 24-10	87.69	April 17,2024 (22 days)	1.3 (86.4)

Based on the April 17,2024 set of measurements, the groundwater level ranges from 1.1 m to 2.7 m depths (Elevation 86.4 m to Elevation 84.6 m).

The groundwater levels were determined in the boreholes at the time and under the condition stated in the report. Note that fluctuations in the level of groundwater may occur due to a seasonal variation such as precipitation, snowmelt, rainfall activities, and other factors not evident at the time of measurement and therefore may be at a higher level during wet weather periods.

7. Site Classification for Seismic Site Response and Liquefaction Potential of Soils

7.1 Liquefaction Potential of Soils

Liquefaction analysis was conducted using the data collected from the boreholes and the CPTs. The analysis indicates the silty clay above the glacial till is not liquefiable during a seismic event. The analysis indicates the very loose to compact zone of the glacial till is liquefiable during a seismic event with an average factor of safety of less than 1.0. The glacial till is liquefiable in Blocks 3,8,10,12,13 and 15. The glacial till is not liquefiable in Blocks 1,2,6 and 14. Post-liquefaction settlements were calculated to range from 56 mm to 168 mm. The approximate area of the liquefiable glacial till on site is shown in Figure 3. The results of the liquefaction analysis are shown in Appendix F. It is not known if the subsurface soils in Blocks 4,5,7 and 9 are liquefiable. However, since these blocks are located between blocks where the glacial till has been determined to be liquefiable, Blocks 4,5,7 and 9 along with Block 6 are included within the approximate area of the liquefiable glacial till shown in Figure 3.

It is interesting to note that Blocks 1 and 14 are located directly across, north and south of, and in line with The Boys and Girls Club of Ottawa property where EXP conducted a geotechnical investigation for the club in 2021 (EXP Geotechnical report dated March 5,2021 and EXP Project No. OTT-0018293-J5). The 2021 geotechnical investigation indicates that the subsurface soils at the Boys and Girls Club of Ottawa are not liquefiable during a seismic event, which is similar to the findings at Blocks 1 and 14 of the proposed development.

Ground improvement at the site will be required to address the presence of the liquefiable soils to ensure performance of the buildings and basement floor slabs (lowest slabs) during a seismic event. A local specialized contractor was contacted and confirmed that the site can be improved to address the liquefiable soil and to possibly improve the bearing pressures recommended for the footings to support the proposed buildings. The contractor indicated that controlled modulus columns (CMCs) is the most appropriate method to improve the ground at the site.

7.2 Site Classification for Seismic Site Response

Since liquefiable soils have been established on site, Tabbe 4.1.8.4.A of the 2012 OBC (as amended January 2022) indicates that for liquefiable soils, the site classification for seismic response is **Class F.** However, the OBC permits for the determination of the site classification for seismic response, that the presence of liquefiable soils can be ignored, provided the proposed buildings will be designed for a fundamental period of vibration equal to or less than 0.5 seconds.

For the case where the liquefiable soils are ignored by designing the proposed buildings for a fundamental period of vibration equal to or less than 0.5 seconds or are addressed by ground improvement, data from SCPTu 3 and SCPTu 5 was used to determine the site classification for seismic response. SCPTu 3 and SCPTu 5 measured the shear wave velocity within the silty clay and glacial till. The average shear wave velocity was determined to be 125 m/s. Based on an assumed shear wave velocity for the underlying shale bedrock of 1000 m/s from Table 4.1.8.4.A of the 2012 Ontario Building Code (as amended January 1,2022), the weighted average of the shear wave velocity for a 30 m depth is 1164 m/s. Based on Table 4.1.8.4.A of the 2012 OBC (as amended January 2022), for a shear wave velocity of 1164 m/s and that the underside of the footings will be greater than 3.0 m from the bedrock, the classification of the site for seismic response is **Class C.**

7.3 Conclusion

It is EXP's opinion that consideration should be strongly given to improving the ground at the site to address the liquefaction issue to ensure the long-term satisfactory performance of the proposed buildings and basement floor slabs (lowest floor slab) during a seismic event, since the calculated post-liquefaction settlements may render the proposed buildings non-operational. The ground improvement may also increase or improve the bearing pressure at serviceability limit state (SLS) and factored geotechnical resistance at ultimate limit state (ULS) values recommended in this report for the proposed site grade raise.

8. Grade Raise Restrictions

The site is underlain by a sensitive marine clay deposit that is prone to consolidation settlement if overstressed by loads imposed on it by site grade raise, foundations and by the permanent lowering of the groundwater level following construction. Overstressing of the clay will result in its consolidation and subsequent settlement of foundations, which may exceed tolerable limits of the structure resulting in cracking of the structure.

Stantec indicated that the proposed site grade raise in the blocks will be 1.0 m above the elevation of the centreline of the proposed new U-shaped access road. Based on this criterion, a summary of the proposed estimated design grade raise at the block numbers and access road is shown in Table VIII. The information from the boreholes from the current geotechnical investigation and from the 2008 EXP boreholes was used in evaluating the acceptability of the proposed site grade raise. As previously noted, the geodetic ground surface elevations for some of the 2008 borehole/monitoring well locations were interpolated from the spot elevations provided on the 2023 draft functional grading plan by Stantec. Therefore, the ground surface elevations at these borehole locations are considered approximate. The 2008 boreholes/monitoring wells are identified in Table VIII by 08 before the borehole number, for example BH 08-12.

Table VIII: Summary of Proposed Site Grade Raise

Block Number (Building Type)	Closest Boreholes	Proposed Estimated Site Grade Raise (m)
Block 1 (Apartment Building)	BH 23-5 MW08-14 to MW08-17	0.9
Block 2 (Townhouse Building)	BH 23-1 BH 23-2	0.7
Block 3 (Townhouse Building)	BH 23-2	0.5
Block 4 (Townhouse Building)	BH 23-2 BH 23-3	0.5
Block 5 (Townhouse Building)	BH 23-3 BH08-12	0.7
Block 6 (Townhouse Building)	BH 23-3	1.0
Block 7 (Townhouse Building)	BH 23-3	1.0
Block 8 (Townhouse Building)	BH 23-3 BH 23-4	1.4
Block 9 (Townhouse Building)	BH 23-4	1.8
Blocks 10 and 11 (Townhouse Building)	BH 23-4	2.3
Block 12 (Townhouse Building)	BH 23-4 BH 23-7 BH 08-13	2.3
Block 13 (Townhouse Building)	BH 23-7	2.5
Block 14 (Apartment Building)	BH 23-8 BH 23-9 BH 08-10	2.5
Block 15 (Townhouse Building)	BH 23-6 BH 08-11	1.9

Table VIII: Summary of Proposed Site Grade Raise		
Block Number (Building Type)	**Closest Boreholes**	**Proposed Estimated Site Grade Raise (m)**
North Portion of East-West Leg of Subdivision Access Road	BH 23-1	Ranges from Cut Area to 0.3 m Site Grade Raise
North-South Leg of Subdivision Access Road	BH 23-2 BH 08-12	Ranges from Cut Area to 0.8 m Site Grade Raise
South Portion of East-West Leg of Subdivision Access Road	BH 23-8	Rangs from Cut Area to 0.8 m Site Grade Raise

Notes for Table VIII:

1. The draft functional grading plan, Drawing No. GP-1, dated November 15, 2023 (Revision No. 1), prepared by Stantec used to determine the proposed estimated site grade raise.
2. As indicated by Stantec, the proposed grade raise in the blocks was determined by adding 1.0 m to the design centreline elevation of the proposed horizontal U-shaped subdivision access road within the new residential subdivision. The section of the access road opposite the blocks was used in determining the proposed site grade raise for the blocks.
3. The acceptability of the site grade raise has taken into consideration a 0.5 m permanent groundwater lowering.

Based on a review of Table VIII, the estimated grade raise at the blocks and along the subdivision access road is anticipated to range from 0.5 m to 2.5 m. Along the proposed subdivision road, there are some cut areas. The proposed site grade raise indicated for each block and along the proposed subdivision access road are considered acceptable from a geotechnical perspective in conjunction with the recommended SLS and factored ULS values for the footings in Section 10 of this report. It is recommended that should the magnitude of the site grade raise change and be different than indicated in Table VIII, EXP should be contacted to review the acceptability of the site grade raise and provide updated SLS and factored ULS values or footings.

9. Site Grading

Site grading within the **proposed building footprints** should consist of the excavation and removal of the existing fill, soil berms down to the native soils. Site grading will also require the excavation and removal of all surficial topsoil layers, reclaimed asphalt pavement (RAP), fill, buried organic soil layers and organic stained soils down to the native soil which is anticipated to consist of silty clay and glacial till.

For engineered fill pad areas, the native subgrade should be examined by a geotechnician. Any loose/soft areas identified during the subgrade examination should be excavated, removed and replaced with Ontario Provincial Standard Specification (OPSS) Granular B Type II material compacted to 100 percent standard Proctor maximum dry density (SPMDD). Once the subgrade has been approved, the grades may be raised to the design underside footing and floor slab elevation by an engineered fill pad constructed in accordance with Section 10.1 of this report.

Site grading within the **proposed outdoor park, parking lots and access road areas** should consist of the removal of surficial topsoil and organic stained soils. The subgrade should be proofrolled in the presence of a geotechnician. Any loose/soft areas identified during the proofrolling process should be excavated, removed, and replaced with Ontario Provincial Standard Specification (OPSS) Granular B Type II or OPSS Select Subgrade Material (SSM) compacted to 95 percent standard Proctor maximum dry density (SPMDD). Once the subgrade has been approved, the grades may be raised to the design subgrade level of the pavement structure by approved on site material and/or OPSS Select Subgrade Material (SSM) compacted to 95 percent SPMDD.

In place density tests should be performed on each lift of placed material to ensure that it has been compacted to the project specifications.

10. Foundation Considerations

The draft functional grading plan dated November 15, 2023 (Revision No. 1) and prepared by Stantec indicates the site is divided into fifteen (15) building blocks namely Blocks 1 to 15. The residential development will consist of low-rise apartment buildings (2 to 3-storeys) at Blocks 1 and 14 and townhouse-type buildings at the remaining blocks.

It is our understanding that it is proposed to support the new buildings by footings set at a specified underside footing elevation. Stantec indicated that the proposed elevation of the underside of the footing (USF) for the buildings will be 1.8 m below the proposed design elevation of the centreline of the U-shaped access road and the site grade raise will be 1.0 m above the proposed design elevation of the centreline of the proposed new U-shaped access road.

For the blocks located within the approximate area of the liquefiable soil shown in Figure 3, if the post-liquefaction settlements of 56 mm to 168 mm are acceptable and can be tolerated by the building foundations and slab-on-grade, the proposed buildings may be supported by spread and strip footings designed to bear on the native silty clay, glacial till or engineered fill (constructed on the native soils) and the lowest floor slab (basement slab) may be designed as a slab-on-grade supported by the native soils. The footings founded at the estimated underside of footing elevation (USF) determined from the Stantec drawing and indicated in Table IX may be designed for the bearing pressure at SLS and factored ULS values indicated in Table IX.

If the post-liquefaction settlements for the blocks located within the approximate area of the liquefiable soil shown in Figure 3 are not acceptable and cannot be tolerated by the building foundations and slab-on-grade, ground improvement will be required. Once ground improvement has been completed, the proposed buildings may be supported by spread and strip footings founded on the improved soil and the lowest floor slab (basement slab) may be designed as a slab-on-grade supported by the improved soil. The footings founded at the USF indicated in Table IX may be designed for the SLS and factored ULS values recommended in Table IX of this report. The total and differential settlements of the footings founded on the improved soil will be within normally tolerated limits of 25 mm total settlement and 19 m differential settlement. It is possible that the recommended SLS and factored ULS values along with the site grade raise can be increased as a result of the ground improvement.

The existing topsoil, RAP layers, buried organic soil layer and fill (improved or not improved) are not considered suitable to support building foundations and floor slabs.

For the two (2) proposed low-rise apartment buildings (2 to 3-storeys) to be located at Blocks 1 and 14 in a non-liquefiable area, the recommended SLS and factored ULS values for footings may be not sufficient to support the proposed buildings. In this case, the proposed buildings may be supported by pile foundations driven to practical refusal into the underlying shale bedrock and designed in end bearing. Caisson foundations are considered to be problematic due to the high groundwater level in combination with the very loose to compact zone of the silty sand glacial till below the groundwater level. Also, it is anticipated that with caissons, costs will be incurred from the removal and disposal of the soil spoil generated from each caisson. As an alternative to piles, even though Blocks 1 and 14 do not have liquefiable soils, if it is decided to use ground improvement at the other blocks (with liquefiable soils), ground improvement may also be considered for Blocks 1 and 14 to improve the SLS and factored ULS values sufficiently so that the proposed apartment buildings may be supported by footings founded on the improved soil.

Footing and pile foundation are discussed in the following sections of this report.

10.1 Footings

It is considered feasible to support the proposed buildings by strip and spread footings founded at the proposed underside footing elevation on the native soils or on an engineered fill pad constructed on the native soils and designed for the bearing pressure at SLS and factored geotechnical resistance at ULS indicated in Table IX. The bearing pressure at serviceability limit state (SLS) and the factored geotechnical resistance at ultimate limit state (ULS) values provided in Table IX are for a maximum 1.5 m wide strip footing and maximum 3.0 m by 3.0 m square pad footing and for the proposed site grade raise indicated in Table IX. The information from the boreholes and CPTs from the current geotechnical investigation and from the 2008 EXP boreholes were used in determining the SLS and factored ULS values. As previously noted, the geodetic ground surface elevations for some of the 2008 borehole/monitoring well locations were interpolated from the spot elevations provided on the 2023 draft functional grading plan by Stantec. Therefore, the ground surface elevations at these borehole locations are considered approximate. The 2008 boreholes/monitoring wells are identified in Table IX by 08 before the borehole number, for example BH 08-12.

Table IX: Summary of Proposed Site Grade Raise, Founding Elevation and Recommended SLS/Factored ULS Values for Footings for Proposed Buildings

Block Number (Building Type)	Closest Boreholes/Cone Penetration Test (CPT)	Proposed Site Grade Raise (m)	Proposed Underside of Footing Elevation (m)	Founding Material	Bearing Pressure at SLS (kPa)	Factored Geotechnical Resistance at ULS (kPa)
Block 1 (Apartment Building)	BH 23-5 MW08-14 CPTu 1	0.9	85.2	Engineered Fill Pad Constructed Shaley Glacial Till	110	165
Block 2 (Townhouse Building)	BH 24-10	0.7	85.6	Stiff to Very Stiff Silty Clay	175	260
Block 3 (Townhouse Building)	BH 23-2 CPTu 2	0.5	85.6	Loose to Compat Shaley Glacial Till	70	105
Block 4 (Townhouse Building)	BH 08-12	0.5	85.6	Compact Glacial Till	150	225
Block 5 (Townhouse Building)	BH 23-3 BH08-12	0.7	85.7	Very Stiff Silty Clay Compact Glacial Till	80 150	120 225
Block 6 (Townhouse Building)	BH 23-3 SCPTu 3	1.0	85.7	Very Stiff Silty Clay	80	120
Block 7 (Townhouse Building)	BH 23-3	1.0	85.7	Very Stiff Silty Clay	80	120
Block 8 (Townhouse Building)	BH 24-12	1.4	85.8	Stiff Silty Clay	75	110
Block 9 (Townhouse Building)	BH 24-12	1.8	86.0	Stiff Silty Clay	75	110
Blocks 10 and 11 (Townhouse Building)	BH 23-4 SCPTu 5	2.3	86.0	Very Stiff Silty Clay	60	90
Block 12 (Townhouse Block)	BH 24-13	2.3	86.2	Stiff Silty Clay	110	165
Block 13 (Townhouse Building)	BH 23-7 CPTu 6	2.5	86.1	Very Stiff Silty Clay	105	160
Block 14 (Apartment Building)	BH 24-14 BH 23-9 BH 08-10	2.5	85.2	Stiff to Very Stiff Silty Clay	50	75
Block 15 (Townhouse Building)	BH 24-15 CPTu 4	1.9	85.6	Firm to Very Stiff Silty Clay	40	60

Notes for Table IX:

1. The draft functional grading plan, Drawing No. GP-1, dated November 15, 2023 (Revision No. 1), prepared by Stantec was used to determine the proposed site grade raise and underside of footing elevation.
2. As indicated by Stantec, the proposed grade raise in the blocks was determined by adding 1.0 m to the design centreline elevation of the proposed horizontal U-shaped access road within the new residential subdivision. The section of the access road opposite the blocks was used in determining the proposed site grade raise of the blocks.
3. As indicated by Stantec, the underside of footing elevation (USF) was determined by deducting 1.8 m from the design centreline elevation of the proposed horizontal U-shaped access road within the new residential subdivision. The section of the access road opposite the blocks was used in determining the proposed site grade raise of the blocks.
4. The factored geotechnical resistance at ULS includes a geotechnical resistance factor of 0.5.
5. The SLS and factored ULS values have taken into consideration a 0.5 m permanent groundwater lowering.

For footings founded on non-liquefiable soils or on improved ground, total and differential settlements of footings indicated for each block in Table IX will be in the order of 25 mm and 19 mm respectively.

For footings founded on liquefiable soils, the total settlement of the footings will include the sum of the 25 mm and the estimated post-liquefaction settlement of 56 mm to 168 mm resulting in an estimated total settlement of 81 mm to 193 mm. Total differential settlements may be in the approximate order of 61 mm to 145 mm.

As an alternative to the SLS and factored ULS values provided for each block in Table IX, the footings for all the building blocks set at the USF indicated in Table IX may be designed for an overall bearing pressure at SLS of 60 kPa and factored geotechnical resistance at ULS of 90 kPa. The exception to this is Block 1 where a higher SLS of 110 kPa and factored ULS of 160 kPa may be utilized for design purposes and Block 14 and 15 where lower SLS values of 40 kPa and 50 kPa and factored ULS values of 60 kPa and 75 kPa may be used for design purposes.

If the proposed design underside of footing elevation and/or the site grade raise for the blocks and the proposed subdivision access road will be different than indicated in Tables VIII and IX, it is recommended that EXP should be contacted to review the acceptability of the proposed site grade raise and provide updated SLS and factored ULS values for the footings.

Based on recent groundwater level measurements from the boreholes and groundwater level measurements determined from the CPTs, the underside of footing elevations at Blocks 2 to 6, 14 and 15 are approximately 0.3 m to 0.8 m below the groundwater level. The underside of footing elevations in the remaining blocks are at or above the measured groundwater level. It is our understanding that City of Ottawa requirements for gravity driven stormwater drainage systems for developments assumed to be similar to this type of development require the elevation of the underside of the footing (USF) to be at or above the spring line of the storm sewer and above the groundwater level. To satisfy this requirement by the City of Ottawa, consideration should be given to raising the USF elevation where required. The raising of the USF may affect the recommended SLS and factored ULS values provided in Table IX of this report. Therefore, as previously indicated, if the USF elevation will change from those indicated in Table IX, it is recommended that EXP should be contacted to review the revised USF elevations and provide revised SLS and factored ULS values.

The construction of the engineered fill pad should consist of the removal of all existing fill, surficial and buried topsoil (organic) layers and organic stained soils down to the native undisturbed soil. The native subgrade should be examined by a geotechnician. Any loose/soft areas identified during the subgrade examination should be excavated, removed, and replaced with Ontario Provincial Standard Specification (OPSS) Granular B Type II material compacted to 100 percent standard Proctor Maximum Dry Density (SPMDD). Once the native subgrade has been approved, the grades may be raised to the design underside footing and floor slab elevation by the construction of an engineered fill pad. The excavation for the removal of fill and topsoil layers (surficial and buried) and organic stained soils should extend a sufficient distance beyond the limits of the proposed building to accommodate a 1.0 m wide horizontal bench of engineered fill that extends beyond the perimeter of the proposed building on all sides, which should thereafter be sloped at an inclination of 1H to 1V down to the approved subgrade. The engineered fill should consist of OPSS Granular B Type II material that is placed in 300 mm thick lifts and each lift compacted to 100 percent SPMDD. The placement and compaction of the engineered fill can in this way be undertaken to the founding level of the footings. From the footing level to the underside of the floor slab, each lift of the Granular B Type II material should be compacted to 98 percent of SPMDD. The engineered fill should be placed under the full-time supervision of a geotechnician working under the direction of a geotechnical engineer. In-place density tests should be undertaken on each lift of the engineered fill to ensure that it is properly compacted prior to placement of subsequent lift.

For footings founded directly on the approved native soil, the exposed native soil subgrade is susceptible to disturbance due to movement of workers and construction traffic and the prevailing weather conditions during construction. To prevent disturbance to the soil subgrade, the approved footing beds should be covered or protected with a 50 mm thick concrete mud slab within the same day of approval.

All footing beds should be examined by a geotechnical engineer/technician to ensure that the founding surfaces are capable of supporting the design bearing pressure at SLS and that the footing beds have been properly prepared.

A minimum of 1.5 m of earth cover should be provided to the exterior foundations founded on soil of heated structures to protect them from damage due to frost penetration. The frost cover should be increased to 2.1 m for unheated structures if snow will not be removed from their vicinity and to 2.4 m if snow will be removed from the vicinity of the structure. When earth cover is less than the minimum required, an equivalent thermal combination of earth cover and rigid insulation or rigid insulation alone should be provided. EXP can provide developmental comments in this regard, if required.

10.1.1 Footing - Ground Improvement

As previously mentioned, since liquefiable soils have been established at some of the blocks on site, ground improvement can be carried out to address the liquefaction potential of these soils. This improvement can be achieved through the use of Controlled Modus Columns (CMCs) and must be undertaken by a specialist contractor on the basis of end product specifications.

Following the completion of the ground improvement, the proposed buildings may be supported by footings founded on the improved soils and designed for the recommended bearing pressure at SLS and factored geotechnical resistance at ULS. It is possible that the SLS and factored ULS values recommended in this report along with the proposed magnitude of site grade raise may be increased as a result of the ground improvement.

Pre and post construction surveys of nearby buildings and infrastructure (such as underground services) as well as vibration monitoring during ground improvement would be required to ensure that the nearby structures and infrastructure are not adversely impacted by ground improvement.

10.2 Pile Foundations

For the two (2) proposed low-rise apartment buildings (2 to 3-storeys) to be located at Blocks 1 and 14 and in a non-liquefiable area (refer to Figure 3), if the recommended SLS and factored ULS values for footing ae not sufficient to support the proposed buildings, the proposed buildings may be supported by pile foundations. The proposed buildings may be supported by steel H or concrete filled pipe piles designed in end-bearing and driven to practical refusal into the underlying shale bedrock. The bedrock is anticipated to be at 5.5 m to 6.2 m depths (Elevation 82.3 m to Elevation 81.3 m). However, the piles may meet practical refusal at depths below the bedrock surface (5.5 m to 6.2 m depths (Elevation 82.3 m to Elevation 81.3 m).

For piles that are driven to bedrock and designed in end bearing, the piles will have high ultimate geotechnical capacities that may equal or exceed the structural capacity of the steel section of the pile. Therefore, the ultimate geotechnical capacity of the pile at ULS may be taken as equal to the ultimate structural resistance of the steel section of the pile. The factored geotechnical resistance of the pile at ULS is determined by applying a geotechnical resistance factor of 0.4 to the ultimate structural resistance of the pile.

Since the piles are expected to meet refusal in the bedrock, the factored geotechnical resistance at ultimate limit state (ULS) will govern the design. The factored geotechnical resistance values at ULS for various pile sections for Blocks 1 and 14 are shown in Tables X and XI. The factored geotechnical resistance values at ULS are based on steel piles with a yield strength of 350 MPa and concrete compressive strength of 35 MPa and a geotechnical resistance factor of 0.4.

It is noted that the piles will be subjected to down-drag forces (negative skin friction) due to consolidation of the silty clay at Blocks 1 and 14 as a result of the grade raise at the site. The negative skin friction that the piles would be subjected to is also listed in Tables X and XI. The estimated carrying capacity load of a pile may be computed by subtracting the negative skin friction from the factored geotechnical resistance at ULS for Blocks 1 and 14.

Table X: Factored Geotechnical Resistance at Ultimate Limit State (ULS) and Estimated Negative Skin Friction of Steel Pipe and H-Piles – Block 1

Pile Section	Description	Factored Geotechnical Resistance at ULS (kN)	Estimated Negative Skin Friction (kN)	Estimated Load Carrying Capacity of Pile (kN)
Steel Pipe	245 mm O.D. by 10 mm wall thickness	1275	27	1248
	245 mm O.D. by 12 mm wall thickness	1445	27	1418
	324 mm O.D. by 12 mm wall thickness	2120	36	2084
Steel H	HP 310 x 79	1260	42	1218
	HP 310 x 110	1775	43	1732
	HP 310 x 125	2000	44	1956

Table XI: Factored Geotechnical Resistance at Ultimate Limit State (ULS) and Estimated Negative Skin Friction of Steel Pipe and H-Piles – Block 14				
Pile Section	Description	Factored Geotechnical Resistance at ULS (kN)	Estimated Negative Skin Friction (kN)	Estimated Load Carrying Capacity of Pile (kN)
Steel Pipe	245 mm O.D. by 10 mm wall thickness	1275	65	1210
	245 mm O.D. by 12 mm wall thickness	1445	65	1380
	324 mm O.D. by 12 mm wall thickness	2120	86	2034
Steel H	HP 310 x 79	1260	102	1158
	HP 310 x 110	1775	104	1671
	HP 310 x 125	2000	105	1895

Total and differential settlement of the piles are expected to be less than 10 mm.

To achieve the capacity given previously, the pile-driving hammer must seat the pile in the overburden without overstressing the pile material. For guidance purposes, it is estimated that a hammer with rated energy of 54 kJ to 70 kJ (40,000 to 52,000 ft. lbs.) per blow would be required to drive the piles to practical refusal. Practical refusal is considered to have been achieved at a set of 5 blows for 6 mm or less of pile penetration. However, the driving criteria for a particular hammer-pile system must be established at the beginning of the project using the Pile Driving Analyzer.

The piles should be equipped with a driving shoe to protect them from damage during driving as per Ontario Provincial Standard Drawing (OPSD) 3001.100, Type II, Revision No. 2 dated November 2017.

A number of test piles (5 percent of the total number of piles) should be monitored with the Pile Driving Analyzer during the initial driving and re-striking at the beginning of the project. This monitoring will allow for the evaluation of transferred energy into the pile from the hammer, determination of driving criteria and an evaluation of the ultimate bearing capacity of the piles. Depending on the results of the pile driving analysis, the pile capacity may have to be proven by at least one pile load test for each pile type before production piling begins. If necessary, the pile load test should be performed in accordance with the American Society for Testing and Materials (ASTM) D 1143.

Closed end pipe piles tend to displace a relatively large volume of soil. When driven in a cluster or group, they may tend to jack up the adjacent piles in the group. Consequently, the elevation and the location of the top of each pile in a group should be monitored immediately after driving and after all the piles in the group have been driven. This is to ensure that the piles are not heaving or being displaced. Any piles found to heave more than 3 mm should be re-tapped.

Piles driven at the site may be subject to relaxation (loss of set with time). It is therefore recommended that all the piles should be re-tapped at least 24 hours after initially driving and at 24-hour intervals thereafter until it can be proven that relaxation is no longer a problem.

The installation of the piles at the site should be monitored on a full-time basis by a geotechnician working under the direction and supervision of a qualified geotechnical engineer to verify that the piles are driven in accordance with the project specifications.

The concrete grade beams and pile caps for heated structures should be protected from frost action by providing the beams and caps with 1.5 m of earth cover. For non-heated structures, the pile caps and beams should be provided with 2.4 m of earth cover in areas where the snow will be removed and 2.1 m of earth cover where the snow will not be removed. Alternatively, frost protection may be provided by rigid insulation or a combination of rigid insulation and earth cover.

A 50 mm thick concrete mud slab is recommended to installed under the grade beams and pile caps immediately upon excavation and approval of the subgrade to protect the surface of the sandy silt to silty sand and silty clay from disturbance from water, the effects from the weather and foot traffic from construction workers.

Temporary granular roads and mats (at least 900 mm thick) will be required to provide access for the pile driving rig. The actual thickness required for the granular roads and mats will have to be established by the piling contractor, based on the type of piling rig that will be used on site and subsurface condition.

10.3 General Comment

The recommended bearing pressures at SLS and factored geotechnical resistances at ULS have been calculated by EXP from the borehole information for the design stage only. The investigation and comments are necessarily on-going as new information of underground conditions becomes available. For example, more specific information is available with respect to conditions between boreholes, when foundation construction is underway. The interpretation between boreholes and the recommendations of this report must therefore be checked through field monitoring provided by an experienced geotechnical engineer to validate the information for use during the construction stage.

11. Floor Slab and Drainage Requirements

The lowest floor slab (basement slab) for the proposed buildings may be designed and constructed as a slab-on-grade placed on a 200 mm thick, 19 mm sized clear stone bed placed on a minimum 300 mm thick engineered fill pad set on the approved native subgrade constructed in accordance with Section 10.1 of this report. The clear stone will minimize the capillary rise of moisture from the sub-soil to the floor slab. Alternatively, the clear stone layer may be replaced with a 200 mm thick bed of OPSS Granular A overlain by a vapour barrier. Adequate saw cuts should be provided in the floor slabs to control cracking.

The proposed buildings will require a perimeter drainage system. The need for underfloor drainage system for the proposed buildings can be determined once the final design elevation of the basement floor is available.

The floor slab should be set at a minimum of 150 mm higher than the final exterior grade surrounding the buildings.

The final exterior grade surrounding the proposed buildings should be sloped away from the proposed buildings to prevent ponding of surface water close to the exterior walls of the proposed buildings.

12. Lateral Earth Pressure Against Subsurface Walls

The subsurface basement walls for the proposed buildings are typically designed not to support hydrostatic pressure behind the wall. In this case, the subsurface basement walls should be backfilled with free draining material, such as OPSS Granular B Type II compacted to 95 percent SPMDD and equipped with a perimeter drainage system to prevent the buildup of hydrostatic pressure behind the walls. The walls will be subjected to lateral static and dynamic (seismic) earth forces. The expressions below assume free draining backfill material, a perimeter drainage system, level backfill surface behind the wall and vertical face on the back side of the wall.

For design purposes, the lateral static earth thrust against the subsurface walls may be computed from the following equation:

$$P = K_0 h (½ \gamma h + q)$$

where P = lateral earth thrust acting on the subsurface wall, kN/m

K_0 = lateral earth pressure at rest coefficient, assumed to be 0.5 for Granular B Type II backfill material

γ = unit weight of free draining granular backfill; Granular B Type II = 22 kN/m^3

h = depth of point of interest below top of backfill, m

q = surcharge load stress, kPa

The lateral dynamic thrust may be computed from the equation given below:

$$\Delta_{Pe} = \gamma H^2 \frac{a_h}{g} F_b$$

where Δ_{Pe} = dynamic thrust in kN/m of wall

H = height of wall, m

γ = unit weight of backfill material = 22 kN/m^3

$\frac{a_h}{g}$ = earth pressure coefficient or Peak Ground Acceleration (PGA) value, 0.361 for the site (2020 National Building Code of Canada Seismic Hazard Tool)

F_b = thrust factor = 1.0

The dynamic thrust does not take into account the surcharge load. The resultant force acts approximately at 0.63H above the base of the wall.

All subsurface walls should be properly dampproofed.

13. Excavation and De-Watering Requirements

13.1 Excess Soil Management

Ontario Regulation 406/19 specifies protocols that are required for the management and disposal of excess soils. As set forth in the regulation, specific analytical testing protocols need to be implemented and followed based on the volume of soil to be managed and the requirements of the receiving site. The testing protocols are specific as to whether the soils are stockpiled or in situ. In either scenario, the testing protocols are far more onerous than have been historically carried out as part of standard industry practices. These decisions should be factored in and accounted for prior to the initiation of the project-defined scope of work. EXP would be pleased to assist with the implementation of a soil management and testing program that would satisfy the requirements of Ontario Regulation 406/19.

For the environmental aspects of the subsurface soils and groundwater, reference is made to the EXP reports titled, Phase Two Environmental Site Assessment (ESA) and Soil Characterization for the two (2) soil berms on site.

13.2 Excavation

Based on the Stantec draft functional grading plan and site servicing plan, excavations for the construction of the proposed building foundations and installation of the underground services are anticipated to extend to depths ranging from approximately 3.0 m to 4.0 m below existing grade and are expected to be within the fill, silty clay and glacial till and below the groundwater level.

The excavations may be undertaken by conventional heavy equipment capable of removing possible debris within the fill and cobbles and boulders within the glacial till.

Open cut excavations within the soils above the groundwater level are anticipated to be relatively straight forward. If ground improvement is selected to be used on this site, the excavation and dewatering comments and recommendations provided in this report may need to be updated.

All excavations must be undertaken in accordance with the Occupational Health and Safety Act (OHSA), Ontario Reg. 213/91. Based on the definitions provided in OHSA, the subsurface soils on site are considered to be Type 3 and as such must be cut back at 1H:1V from the bottom of the excavation. Within zones of seepage, the excavation side slopes are expected to slough and eventually stabilize at 2H:1V to 3H:1V from the bottom of the excavation. For excavations above the groundwater level or properly dewatered (refer to paragraph below), the installation of the municipal underground services may be undertaken within the confines of a prefabricated support system (trench box) designed and installed in accordance with OHSA.

Open cut excavations that extend into the silty sand to sandy silt glacial till below the groundwater level are anticipated to be more problematic and will require the lowering of the groundwater level prior to the start of excavation. It is anticipated that the base of the excavation in the silty sand to sandy silt glacial till and below the groundwater level may be susceptible to basal instability or base type failure in the form of piping or heave. To minimize the occurrence of base type failure, it is recommended that the groundwater level should be lowered by at least 1.0 m below the bottom of the excavation prior to the start of excavation. This may be achieved by installing deep sumps and pumping with high-capacity pumps. The dewatering contractor should review the subsurface conditions at the site and select the most appropriate method to lower the groundwater level.

Many geologic materials deteriorate rapidly upon exposure to meteorological elements. Unless otherwise specifically indicated in this report, walls and floors of excavations must be protected from moisture, desiccation, and frost action throughout the course of construction.

13.3 De-Watering Requirements

Seepage of the surface and subsurface water into the excavations is anticipated. However, it should be possible remove groundwater entering into excavation by pumping from sumps. In areas of high infiltration or in areas where more permeable soil layers may exist, a higher seepage rate should be anticipated and will require high-capacity pumps to keep the excavation dry (may need to operate 24 hours a day, seven (7) days a week).

As discussed above, to minimize base type failure of excavations that extend below the groundwater level and into the silty sand to sandy silt glacial till, it is recommended that the groundwater level should be lowered by at least 1.0 m below the bottom of

the excavation for the proposed buildings and underground services prior to the start of excavation. These may be achieved by installing deep sumps and pumping with high-capacity pumps. The dewatering contractor should review the subsurface conditions at the site and select the most appropriate method to lower the groundwater level.

For construction dewatering, an Environmental Activity and Sector Registry (EASR) approval may be obtained for water takings greater than 50 m^3 and less than 400 m^3 per day. If more than 400 m^3 per day of groundwater are generated for dewatering purposes, then a Category 3 Permit to Take Water (PTTW) must be obtained from the Ministry of the Environment, Conservation and Parks (MECP). A Category 3 PTTW would require a complete hydrogeological assessment and would take at least 90 days for the MECP to process once the application is submitted.

Although this investigation has estimated the groundwater levels at the time of the fieldwork, and commented on dewatering and general construction problems, conditions may be present which are difficult to establish from standard boring and excavating techniques and which may affect the type and nature of dewatering procedures used by the contractor in practice. These conditions include local and seasonal fluctuations in the groundwater table, erratic changes in the soil profile, thin layers of soil with large or small permeabilities compared with the soil mass, etc. Only carefully controlled tests using pumped wells and observation wells will yield the quantitative data on groundwater volumes and pressures that are necessary to adequately engineer construction dewatering systems.

14. Pipe Bedding Requirements

It is anticipated that the subgrade for the proposed underground services will consist of existing fill, native silty clay and glacial till.

The pipe bedding including material specifications, thickness of cover material and compaction requirements should conform to City of Ottawa specifications, drawings and special provisions. The bedding and cover material should be compacted to a minimum of 95 percent standard Proctor maximum dry density (SPMDD).

The bedding thickness may be increased in areas where the subgrade is subject to disturbance. If this is the case, trench base stabilization techniques, such as the removal of loose material, placement of sub-bedding, consisting of OPSS Granular B Type II completely wrapped in a non-woven geotextile, may be used.

For paved surfaces that will be located over service trenches, it is recommended that the trench backfill material within the 1.8 m frost zone, should match the existing material exposed along the trench walls to minimize differential frost heaving of the subgrade. The trench backfill should be placed in 300 mm thick lifts and each lift should be compacted to 95 percent SPMDD. Alternatively, frost tapers may be used.

If the backfill for the service trenches will consist of granular fill, clay seals should be installed in the service trenches at select intervals (spacing) as per City of Ottawa Drawing No. S8. The seals should be 1 m wide, extend over the entire trench width and from the bottom of the trench to the underside of the pavement structure. The clay should be compacted to 95 percent SPMDD. The purpose of the clay seals is to prevent the permanent lowering of the groundwater level.

The underground services should be installed in short open trench sections that are excavated and backfilled the same day.

15. Backfilling Requirements and Suitability of On-Site Soils for Backfilling Purposes

The materials to be excavated from the site will comprise of topsoil, buried organic soil, fill, silty clay and glacial till. From a geotechnical perspective, the topsoil, buried organic soil and fill are not considered suitable for reuse as backfill material in the interior or exterior of the buildings and should be discarded. These soils may be used for general grading purposes in landscaped areas. Portions of the fill, silty clay and glacial till (free of cobbles and boulders) above the groundwater level may be re-used as fill in locations away from the proposed buildings as backfill in service trenches and subgrade fill in paved and landscaped areas, subject to further geotechnical examination and testing during construction. These soils are subject to moisture absorption due to precipitation and must be protected at all times from the elements. Subject to additional examination and testing during construction, portions of the fill, silty clay and glacial till (free of cobbles and boulders) below the groundwater level, may be re-used as fill in locations away from the proposed buildings as backfill in service trenches and subgrade fill in paved and landscaped areas, but will likely require air-drying to reduce the moisture content to compact the materials to the specified degree of compaction. Air-drying may be problematic (difficult) since it is weather dependent, may take time and that the soils are subject to moisture absorption from precipitation and must be protected at all times from the elements.

For the environmental aspects of the existing soil, reference should be made to the EXP Phase One and Two Environmental Site Assessments (ESAs) and the Site-Specific Risk Assessment (SSRA).

The soils in the berms on site may be re-used as fill in locations away from the proposed buildings, as backfill in service trenches and subgrade fill in paved and landscaped areas, subject to further geotechnical examination and testing during construction and provided that these soils are suitable for re-use on the site from an environmental perspective. Reference is made to the Soil Characterization for the two (2) soil berms on site regarding the suitability of the soils in the berms for re-use on site from an environmental perspective.

Therefore, it is anticipated that the majority of the material required for backfilling purposes in the interior and exterior of the proposed buildings and in the underground service trenches will need to be imported and should preferably conform to the following specifications:

- Engineered fill under footings for the proposed buildings – OPSS Granular B Type II placed in 300 mm thick lifts and each lift compacted to 100 percent SPMDD,
- Engineered fill under the floor slab of the proposed buildings – OPSS Granular B Type II placed in 300 mm thick lifts and each lift compacted to 98 percent SPMDD,
- Backfill material for footing trenches and against foundation walls located outside the proposed buildings – OPSS Granular B Type II placed in 300 mm thick lifts and each lift compacted to 95 percent SPMDD,
- Trench backfill and subgrade fill should consist of OPSS Granular B Type I or OPSS Select Subgrade Material (SSM) placed in 300 mm thick lifts and each lift compacted to 95 percent SPMDD; and
- Landscaped areas - Clean fill that is free of organics and deleterious material, cobbles and boulders and is placed in 300 mm thick lifts with each lift compacted to 92 percent of the SPMDD.

16. Pavement Structures for Access Road and Parking Lots

The subgrade for the pavement structures is anticipated to consist of fill, native silty clay, OPSS Granular B Type II material and OPSS Select Subgrade Material (SSM). Pavement structure thicknesses required for the access road and parking lots set on the anticipated approved subgrade materials were computed and are shown in Table XII. The pavement structures assume a functional design life of 15 to 20 years. The proposed functional design life represents the number of years to the first rehabilitation, assuming regular maintenance is carried out.

Table XII: Recommended Pavement Structure Thicknesses

Pavement Layer	Compaction Requirements	Computed Pavement Structure	
		Light Duty Traffic (Cars Only)	Heavy Duty Traffic – Access Road (Emergency Vehicles and Trucks)
Asphaltic Concrete	92 percent-97 percent MRD	65 mm HL3/SP12.5 mm/ Cat. B (PG 58-34)	50 mm HL3/SP12.5 Cat. B (PG 58-34) 60 mm HL8/SP 19 Cat. B (PG 58-34)
OPSS 1010 Granular A Base	100% percent SPMDD	150 mm	150 mm
OPSS 1010 Granular B Type II Sub-base	100% percent SPMDD	450 mm	600 mm

Notes:

1. SPMDD denotes standard Proctor maximum dry density, ASTM, D-698-12e2.
2. MRD denotes Maximum Relative Density, ASTM D2041.
3. The upper 300 mm of the subgrade fill must be compacted to 98 percent SPMDD.
4. The approved subgrade should be covered with a woven geotextile prior to placement of granular sub-base of the pavement structure.

The foregoing design assumes that construction is carried out during dry periods and that the subgrade is stable under the load of construction equipment. If construction is carried out during wet weather and heaving or rolling of the subgrade is experienced, additional thickness of granular material may be required in addition to the woven geotextile indicated in Table XI.

Additional comments for the construction of the access road and parking lots are as follows:

1. As part of the subgrade preparation, the proposed parking areas and the internal access road should be stripped of surficial topsoil and organic stained soil. The subgrade should be properly shaped, crowned, then proofrolled with a heavy vibratory roller in the full-time presence by a geotechnician. Any soft or spongy subgrade areas detected should be sub excavated and properly replaced with suitable approved material or approval OPSS Granular B Type II placed in 300 mm lift and each lift compacted to 95 percent SPMDD (ASTM D698-12e2).
2. The long-term performance of the pavement structure is highly dependent upon the subgrade support conditions. Stringent construction control procedures should be maintained to ensure that uniform subgrade moisture and density conditions are achieved. The need for adequate drainage cannot be over-emphasized. Subdrains should be installed on both sides of the access road(s). Subdrains must be installed in the proposed parking area and on both sides of the roadways at low points and should be continuous between catchbasins to intercept excess surface and subsurface moisture and to prevent subgrade softening. This will ensure no water collects in the granular course, which could result in pavement failure during the spring thaw. The location and extent of sub drainage required within the paved areas should be reviewed by this office in conjunction with the proposed site grading.
3. To minimize the problems of differential movement between the pavement and catchbasins/manhole due to frost action, the backfill around the structures should consist of free-draining granular preferably conforming to OPSS Granular B Type II material. Weep holes should be provided in the catchbasins/manholes to facilitate drainage of any water that may accumulate in the granular fill.

4. The most severe loading conditions on light-duty pavement areas and the subgrade may occur during construction. Consequently, special provisions such as restricted lanes, half-loads during paving, temporary construction roadways, etc., may be required, especially if construction is carried out during unfavorable weather.
5. The finished pavement surface should be free of depressions and should be sloped (preferably at a minimum cross fall of 2 percent) to provide effective surface drainage towards catchbasins. Surface water should not be allowed to pond adjacent to the outside edges of paved areas.
6. Relatively weaker subgrade may develop over service trenches at subgrade level. These areas may require the use of thicker/coarser sub-base material and the use of a geotextile at the subgrade level. if this is the case, it is recommended that additional 150 mm of granular sub-base Granular B Type II should be provided in these areas in addition to the use of a geotextile at the subgrade level.
7. The granular materials used for pavement construction should conform to OPSS 1010 for Granular A and Granular B Type II and should be compacted to 100 percent of the SPMDD (ASTM D698). The asphaltic concrete and its placement should meet OPSS requirements. It should be compacted to 92 to 97 percent of the maximum relative density in accordance with ASTM D2041.

The asphaltic concrete used, and its placement should meet OPSS 1150 or 1151 requirements. It should be compacted from 92 percent to 97 percent of the MRD (ASTM D2041). Asphalt placement should be in accordance with OPSS 310 and OPSS 313.

It is recommended that EXP be retained to review the final pavement structure design and drainage plans prior to construction to ensure they are consistent with the recommendations of this report.

17. Corrosion Potential

Chemical tests limited to pH, sulphate, chloride and resistivity were undertaken on three (3) soil samples. A summary of the results is shown in Table XIII. The laboratory certificate of analysis is shown in Appendix G.

Table XIII: Corrosion Test Results on Soil Samples

Borehole – Sample No.	Depth (m)	Soli Type	pH	Sulphate (%)	Chloride (%)	Resistivity (ohm-cm)
BH 23-2 SS5	3.0 m - 3.6 m	Shaley Glacial Till	8.33	0.0167	0.0039	2430
BH 23-4 SS4	3.0 m - 3.6 m	Grey Silty Clay	7.97	0.0134	0.0256	1070
BH 23-8 SS5	3.8 m - 4.4 m	Shaley Glacial Till	7.95	0.0205	0.1100	296

The results indicate the soils have a negligible sulphate attack on subsurface concrete. The concrete should be designed in accordance with CSA A.23.1-19.

The results from the resistivity tests indicate that the shaley glacial till is mildly to very corrosive, and the grey silty clay is moderately corrosive to corrosive to bare steel as per the National Association of Corrosion Engineers (NACE). Appropriate measures should be taken to protect the buried bare steel from corrosion.

18. Tree Planting Restrictions

Based on the results of the Atterberg limits of the clayey soils and comparison of the results with the City of Ottawa 2005 Clay Soils Policy and 2017 Tree Planting in Sensitive Marine Clay Soils Guidelines (2017 Tree Planting Guidelines), the clayey soils at this site are considered to have a low/medium potential for soil volume change. Therefore, the tree planting should be carried out in accordance with the 2017 City of Ottawa Tree Planting Guidelines.

A landscape architect should be consulted to ensure the tree planting restrictions and setbacks for the proposed development are in accordance with the applicable City of Ottawa guidelines.

19. General Comments

The comments given in this report are intended only for the guidance of design engineers. The number of boreholes required to determine the localized underground conditions between boreholes affecting construction costs, techniques, sequencing, equipment, scheduling, etc., would be much greater than has been carried out for the design purposes. Contractors bidding on or undertaking the works should, in this light, decide on their own investigations, as well as their own interpretations of the factual borehole results, so that they may draw their own conclusions as to how the subsurface conditions may affect them.

The information contained in this report is not intended to reflect on environmental aspects of the soils and groundwater. Reference should be made to the Phase One and Two Environmental Site Assessments (ESAs), the Site-Specific Risk Assessment (SSRA) and the Soil Characterization of the two (2) soil berms on site for the environmental aspects of the soils and groundwater.

We trust that the information contained in this report will be satisfactory for your purposes. Should you have any questions, please do not hesitate to contact this office.

Sincerely

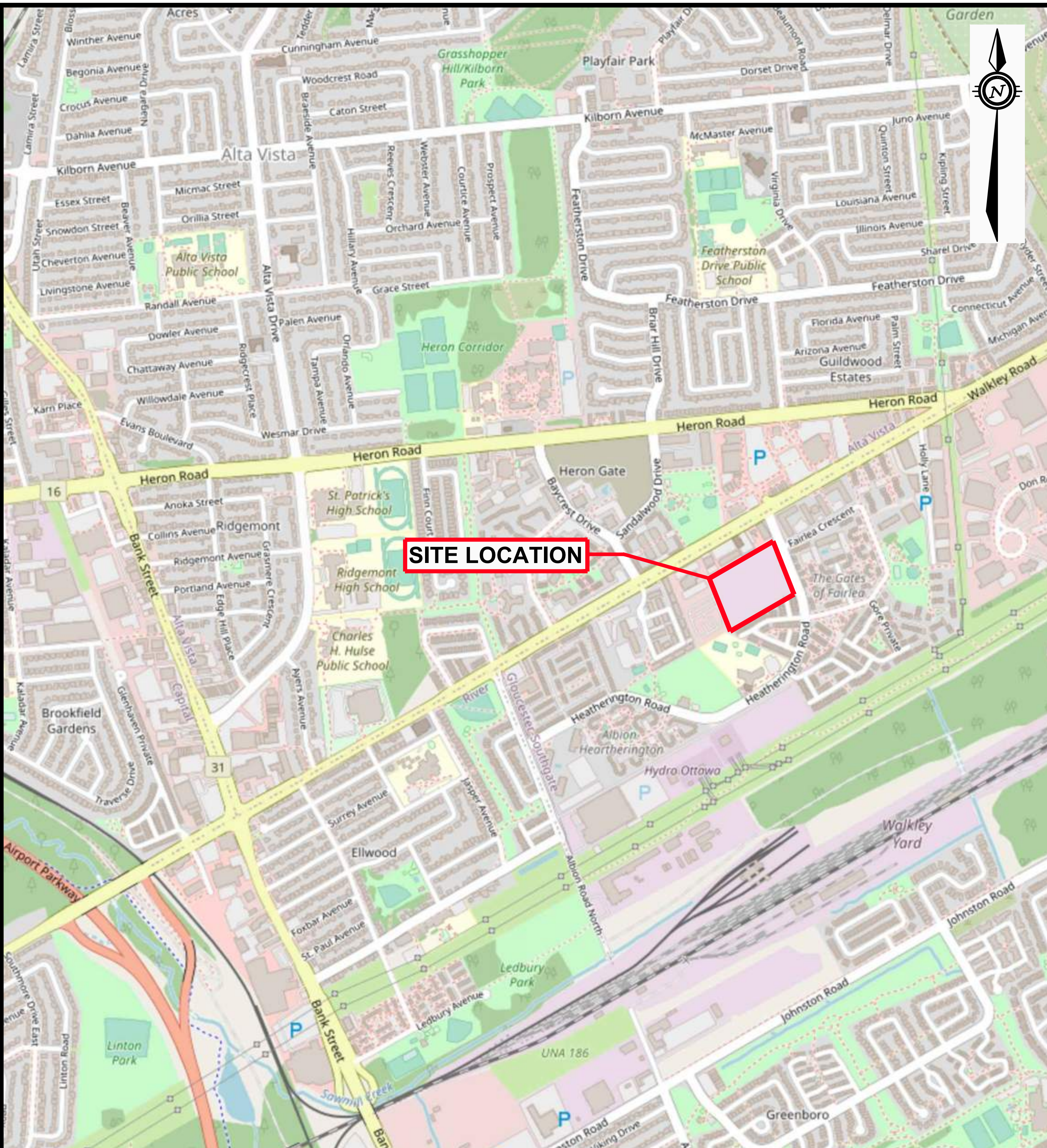
DRAFT

Susan M. Potyondy, P.Eng.
Senior Geotechnical Engineer
Earth & Environment
Eastern Region

DRAFT

Ismail M. Taki, M.Eng., P.Eng.
Senior Manager
Earth & Environment
Eastern Region

Figures



0 150m 300m 600m

HORIZONTAL 1:15,000

EXP Services Inc.
100-2650 Queensview Drive
Ottawa, ON K2B 8H6
www.exp.com

DESIGN	I.T.
DRAWN	A.S.
DATE	NOVEMBER 2023
FILE NO	OTT-22026647-A0

GEOTECHNICAL INVESTIGATION
Proposed Residential Development
1770 Heatherington Road, Ottawa, Ontario

SITE LOCATION PLAN

SCALE 1:15,000

SKETCH NO

FIG 1

Filename: \\exp\data\OTT\OTT-22026647-A0\60 Execution\65 Drawings\OTT-22026647-A0_Geo – Rev1.dwg
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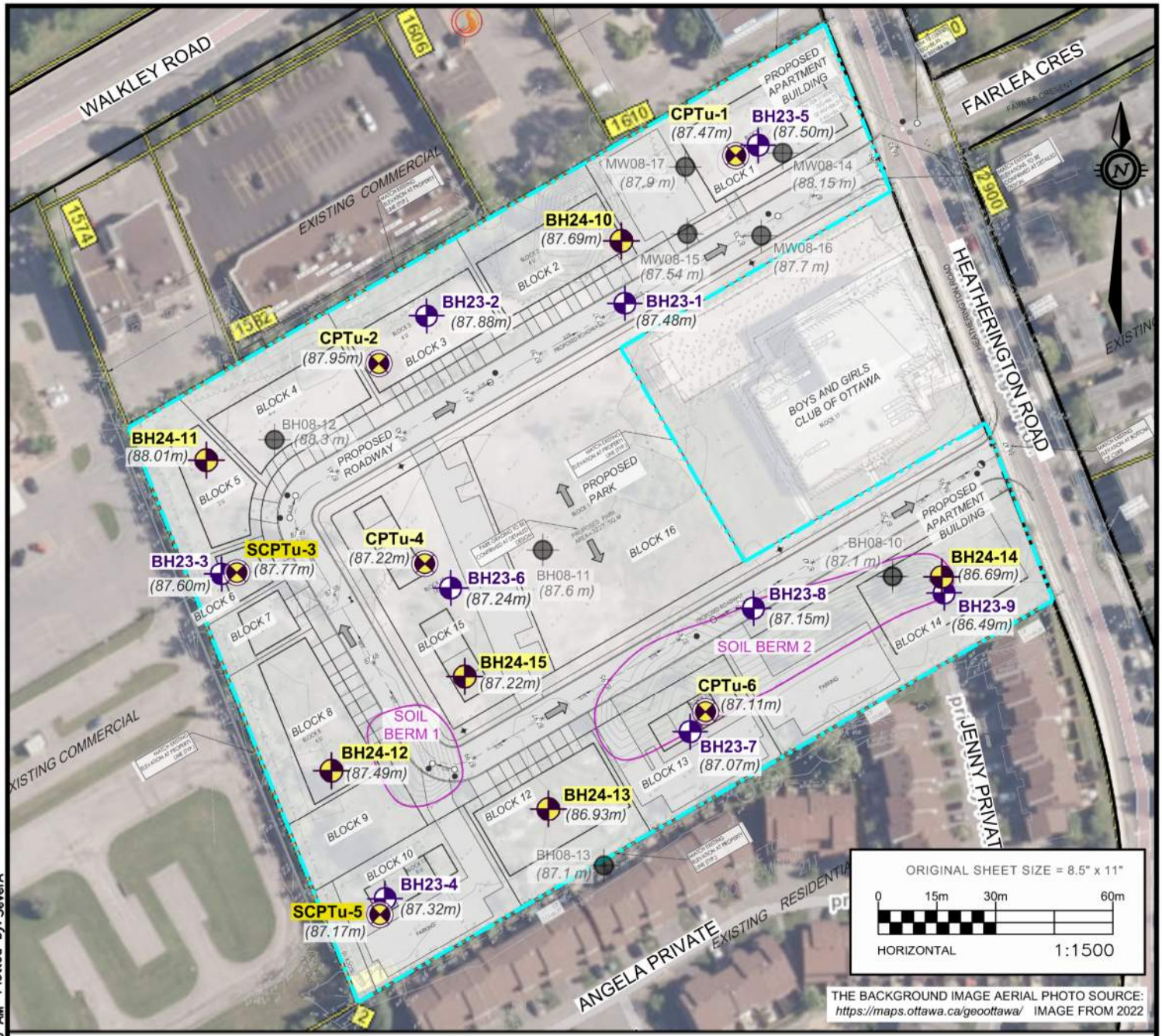

LEGEND

	PROPERTY BOUNDARY
BH24-10	2024 BOREHOLE NO. AND LOCATION
CPTu-1	2024 CONE PENETRATION TEST CAPABLE OF MEASURING PORE PRESSURE
SCPTu-3	2024 CONE PENETRATION TEST CAPABLE OF MEASURING PORE PRESSURE AND SHEAR WAVE VELOCITY (SEISMIC)
BH23-1	2023 BOREHOLE NO. AND LOCATION
(87.48m)	GROUND SURFACE ELEVATION (m)
MW-08-11	2008 BOREHOLE NO. AND LOCATION
(87.6m)	GROUND SURFACE ELEVATION (m)

NOTES:

1. THE BOUNDARIES, ROCK AND SOIL TYPES HAVE BEEN ESTABLISHED ONLY AT BOREHOLE LOCATIONS. BETWEEN BOREHOLES THEY ARE ASSUMED AND MAY BE SUBJECT TO CONSIDERABLE ERROR.
2. ROCK AND SOIL SAMPLES WILL BE RETAINED IN STORAGE FOR THREE MONTHS AND THEN DESTROYED UNLESS THE CLIENT ADVISES THAT AN EXTENDED TIME PERIOD IS REQUIRED.
3. TOPSOIL QUANTITIES SHOULD NOT BE ESTABLISHED FROM THE INFORMATION PROVIDED AT THE BOREHOLE LOCATIONS.
4. BOREHOLE ELEVATIONS SHOULD NOT BE USED TO DESIGN BUILDING(S) OR FLOOR SLABS OR PARKING LOT(S) GRADES.
5. THIS DRAWING FORMS PART OF THE REPORT PROJECT NUMBER AS REFERENCED AND SHOULD BE USED ONLY IN CONJUNCTION WITH THIS REPORT.
6. THE BASE GRADING PLAN DRAWING PRODUCED BY *STANTEC CONSULTING LTD.*, PROJECT NO.: 160401774, DWG. NO.: GP-1, DATED: 2023.11.15
7. THE GROUND SURFACE ELEVATION FOR BH23-5, BH08-14 and BH08-15 ARE ESTIMATED FROM GRADING PLAN PREPARED BY *STANTEC*, DATED 2023.11.15

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DESIGN	S.P.
DRAWN	A.S.
DATE	MAY 2024
FILE NO	OTT-22026647-A0

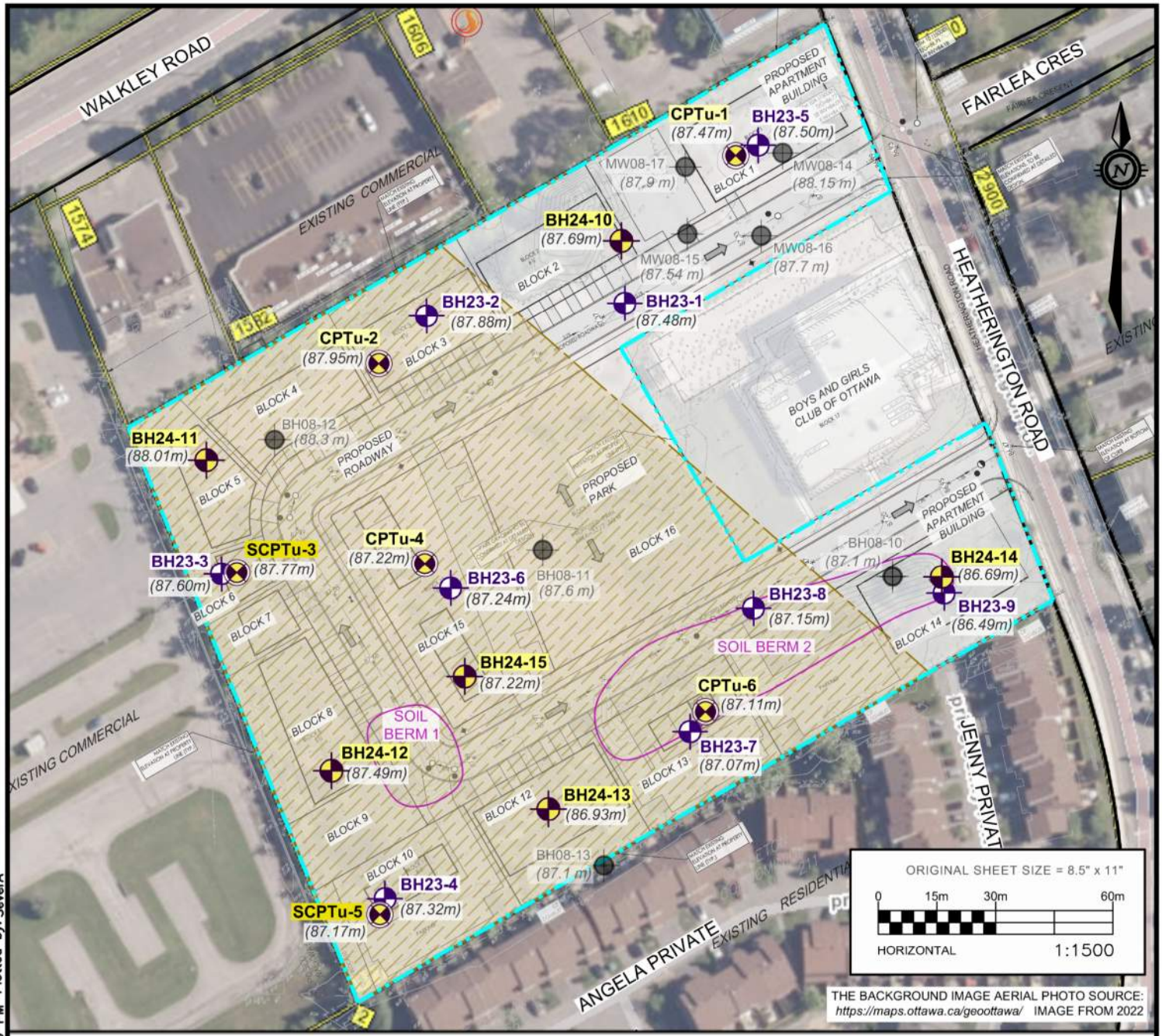
GEOTECHNICAL INVESTIGATION

Proposed Residential Development
1770 Heatherington Road, Ottawa, Ontario

TEST HOLE LOCATION PLAN

SCALE 1:1,500

SKETCH NO FIG 2



LEGEND

- PROPERTY BOUNDARY
- **BH24-10** — 2024 BOREHOLE NO. AND LOCATION
- **CPTu-1** — 2024 CONE PENETRATION TEST CAPABLE OF MEASURING PORE PRESSURE
- **SCPTu-3** — 2024 CONE PENETRATION TEST CAPABLE OF MEASURING PORE PRESSURE AND SHEAR WAVE VELOCITY (SEISMIC)
- **BH23-1** — 2023 BOREHOLE NO. AND LOCATION
- *(87.48m)* — GROUND SURFACE ELEVATION (m)
- MW-08-11 — 2008 BOREHOLE NO. AND LOCATION
- *(87.6m)* — GROUND SURFACE ELEVATION (m)

NOTES:

1. THE BOUNDARIES, ROCK AND SOIL TYPES HAVE BEEN ESTABLISHED ONLY AT BOREHOLE LOCATIONS. BETWEEN BOREHOLES THEY ARE ASSUMED AND MAY BE SUBJECT TO CONSIDERABLE ERROR.
2. ROCK AND SOIL SAMPLES WILL BE RETAINED IN STORAGE FOR THREE MONTHS AND THEN DESTROYED UNLESS THE CLIENT ADVISES THAT AN EXTENDED TIME PERIOD IS REQUIRED.
3. TOPSOIL QUANTITIES SHOULD NOT BE ESTABLISHED FROM THE INFORMATION PROVIDED AT THE BOREHOLE LOCATIONS.
4. BOREHOLE ELEVATIONS SHOULD NOT BE USED TO DESIGN BUILDING(S) OR FLOOR SLABS OR PARKING LOT(S) GRADES.
5. THIS DRAWING FORMS PART OF THE REPORT PROJECT NUMBER AS REFERENCED AND SHOULD BE USED ONLY IN CONJUNCTION WITH THIS REPORT.
6. THE BASE GRADING PLAN DRAWING PRODUCED BY *STANTEC CONSULTING LTD.*, PROJECT NO.: 160401774, DWG. NO.: GP-1, DATED: 2023.11.15
7. THE GROUND SURFACE ELEVATION FOR BH23-5, BH08-14 and BH08-15 ARE ESTIMATED FROM GRADING PLAN PREPARED BY *STANTEC*, DATED 2023.11.15

APPROXIMATE LIMIT OF AREA WITH LIQUEFIABLE GLACIAL TILL

EXP Services Inc.
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DESIGN	S.P.
DRAWN	A.S.
DATE	MAY 2024
FILE NO	OTT-22026647-A0

GEOTECHNICAL INVESTIGATION
Proposed Residential Development
1770 Heatherington Road, Ottawa, Ontario

APPROXIMATE LIMIT OF LIQUEFIABLE GLACIAL TILL

SCALE 1:1,500

SKETCH NO **FIG 3**

Filename: E:\OTT\OTT-22026647-A0\60 Execution\65 Drawings\OTT-22026647-A0_Geo.dwg
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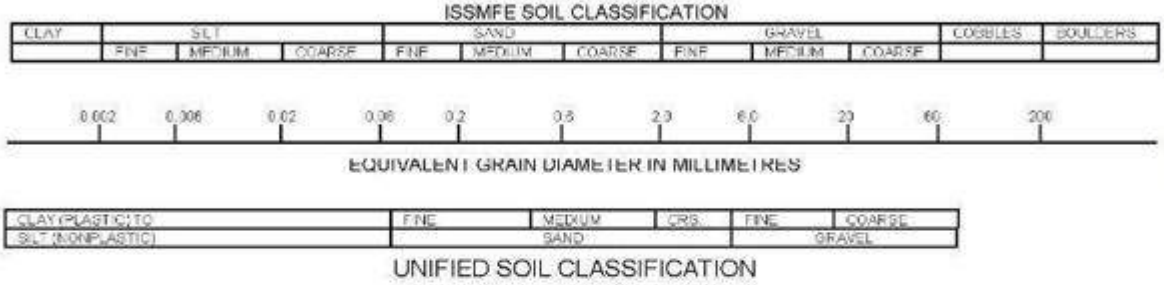
Notes On Sample Descriptions

1. All sample descriptions included in this report follow the Canadian Foundations Engineering Manual soil classification system. This system follows the standard proposed by the International Societv for Soil Mechanics and Foundation Engineering. Laboratory grain size analyses provided by **exp** Services Inc. also follow the same system. Different classification systems may be used by others; one such system is the Unified Soil Classification. Please note that, with the exception of those samples where a grain size analysis has been made, all samples are classified visually. Visual classification is not sufficiently accurate to provide exact grain sizing or precise differentiation between size classification systems.



2. Fill: Where fill is designated on the borehole log it is defined as indicated by the sample recovered during the boring process. The reader is cautioned that fills are heterogeneous in nature and variable in density or degree of compaction. The borehole description may therefore not be applicable as a general description of site fill materials. All fills should be expected to contain obstruction such as wood, large concrete pieces or subsurface basements, floors, tanks, etc., none of these may have been encountered in the boreholes. Since boreholes cannot accurately define the contents of the fill, test pits are recommended to provide supplementary information. Despite the use of test pits, the heterogeneous nature of fill will leave some ambiguity as to the exact composition of the fill. Most fills contain pockets, seams, or layers of organically contaminated soil. This organic material can result in the generation of methane gas and/or significant ongoing and future settlements. Fill at this site may have been monitored for the presence of methane gas and, if so, the results are given on the borehole logs. The monitoring process does not indicate the volume of gas that can be potentially generated nor does it pinpoint the source of the gas. These readings are to advise of the presence of gas only, and a detailed study is recommended for sites where any explosive gas/methane is detected. Some fill material may be contaminated by toxic/hazardous waste that renders it unacceptable for deposition in any but designated land fill sites; unless specifically stated the fill on this site has not been tested for contaminants that may be considered toxic or hazardous. This testing and a potential hazard study can be undertaken if requested. In most residential/commercial areas undergoing reconstruction, buried oil tanks are common and are generally not detected in a conventional geotechnical site investigation.

3. Till: The term till on the borehole logs indicates that the material originates from a geological process associated with glaciation. Because of this geological process the till must be considered heterogeneous in composition and as such may contain pockets and/or seams of material such as sand, gravel, silt or clay. Till often contains cobbles (60 to 200 mm) or boulders (over 200 mm). Contractors may therefore encounter cobbles and boulders during excavation, even if they are not indicated by the borings. It should be appreciated that normal sampling equipment cannot differentiate the size or type of any obstruction. Because of the horizontal and vertical variability of till, the sample description may be applicable to a very limited zone; caution is therefore essential when dealing with sensitive excavations or dewatering programs in till materials.

Log of Borehole BH23-1

Project No: OTT-22026647-A0

Project: Proposed Residential Development

Location: 1770 Heatherington Road, Ottawa, ON

Figure No. 4

Page. 1 of 1

Date Drilled: 'November 30, 2023

Drill Type: CME 45 Track-Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: M.Z. Checked by: I.T.

Split Spoon Sample ⊠ | Auger Sample ◧ | SPT (N) Value ○ | Dynamic Cone Test —— | Shelby Tube ■ | Shear Strength by Vane Test +S

Combustible Vapour Reading □ | Natural Moisture Content × | Atterberg Limits —○— | Undrained Triaxial at % Strain at Failure ⊕ | Shear Strength by Penetrometer Test ▲

Depth	Geodetic Elevation m	SOIL DESCRIPTION	Standard Penetration Test N Value / Shear Strength kPa	Combustible Vapour Reading (ppm) / Natural Moisture Content % / Atterberg Limits (% Dry Weight)	SAMPLES	Natural Unit Wt. kN/m³
0	87.48	**RECLAIMED ASPHALT PAVEMENT (RAP)** ~ 75 mm thick	24	×	SS1	
	87.4					
	86.8	**FILL** Silty sand, some gravel, dark brown to black, moist, (compact)				
1			7	×	SS2	
		SILTY CLAY Brown, moist, (very stiff)	140 kPa s=9.3			
2	85.4	**SILTY CLAY** Medium plasticity, trace sand, grey, wet, (firm)	2	×	SS3	
3			29 kPa s=12.0			
			1	×	SS4	
4			29 kPa s=4.0			
	83.2	**SHALEY GLACIAL TILL** Silty sand, some fine gravel sized shale fragments, some clay seams, possible cobbles and boulders, dark grey, wet, (compact)				
5			23	×	SS5	
6	81.3	**HIGHLY WEATHERED SHALE BEDROCK**	59	×	SS6	
	80.8	Gravel sized shale fragments, some sand, dark grey, moist				
7		**SHALE BEDROCK** Dark grey to black, (very poor to fair quality)			RUN 1	
8					RUN 2	
9					RUN 3	
	77.7	**Borehole Terminated at 9.8 m Depth**				

LOG OF BOREHOLE LOGS OF BOREHOLES 02.13.2024.GPJ TROW OTTAWA.GDT 05/08/24

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. Borehole was backfilled upon completion.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-22026647-A0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %
1	6.7 - 7.6	100	0
2	7.6 - 9.3	89	59
3	9.3 - 9.8	100	48

Log of Borehole BH23-2

Project No: OTT-22026647-A0

Project: Proposed Residential Development

Location: 1770 Heatherington Road, Ottawa, ON

Figure No. 5

Page. 1 of 1

Date Drilled: 'December 1, 2023

Drill Type: CME 45 Track-Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: M.Z. Checked by: I.T.

Split Spoon Sample ⊠ | Auger Sample ◧ | SPT (N) Value ○ | Dynamic Cone Test —— | Shelby Tube ■ | Shear Strength by Vane Test +S

Combustible Vapour Reading □ | Natural Moisture Content × | Atterberg Limits ⊢○ | Undrained Triaxial at % Strain at Failure ⊕ | Shear Strength by Penetrometer Test ▲

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth	Standard Penetration Test N Value / Shear Strength kPa	Combustible Vapour Reading (ppm) / Natural Moisture Content % / Atterberg Limits (% Dry Weight)	SAMPLES	Natural Unit Wt. kN/m³
		FILL Silty sand, some gravel, trace grey, with occasional rootlets, brown, moist, (loose)	87.88	0	8		SS1	
		ORGANIC CLAYEY SILT ~ 130 mm thick Dark brown, moist	87.1 / 87.0					
		SILTY CLAY Brown, moist, (firm)		1	12		SS2	
			86.18	2	6		SS3	
		SHALEY GLACIAL TILL Silty sand, some clay seams of low plasticity, trace fine gravel sized shale fragments, possible cobbles and boulders, dark grey, wet, (loose to compact)	85.7	3	7		SS4	
					4		SS5	
				4				
				5	18		SS6	
		HIGHLY WEATHERED SHALE BEDROCK Gravel sized shale fragments, some silty sand, dark grey, moist	82.3 / 81.6	6	4 then 30/50mm		SS7	
		Auger Refusal at 6.3 m Depth						

LOG OF BOREHOLE LOGS OF BOREHOLES 02.13.2024.GPJ TROW OTTAWA.GDT 05/08/24

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. 32 mm monitoring well installed upon completion
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-22026647-A0

WATER LEVEL RECORDS		
Date	Water Level (m)	Hole Open To (m)
January 9, 2024	1.9	6.3
April 17, 2024	1.7	

CORE DRILLING RECORD			
Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH23-3

Project No: OTT-22026647-A0

Project: Proposed Residential Development

Location: 1770 Heatherington Road, Ottawa, ON

Figure No. 6

Page. 1 of 1

Date Drilled: 'November 23, 2023

Drill Type: CME 45 Track-Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: J.E. Checked by: I.T.

Split Spoon Sample ⊠ | Auger Sample ◧ | SPT (N) Value ○ | Dynamic Cone Test —— | Shelby Tube ■ | Shear Strength by Vane Test +S

Combustible Vapour Reading □ | Natural Moisture Content × | Atterberg Limits ⊢○⊣ | Undrained Triaxial at % Strain at Failure ⊕ | Shear Strength by Penetrometer Test ▲

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth	Standard Penetration Test N Value / Shear Strength kPa	Combustible Vapour Reading (ppm) / Natural Moisture Content % / Atterberg Limits (% Dry Weight)	SAMPLES	Natural Unit Wt. kN/m³
		FILL Mixture of silty sand and silty clay, brown to dark grey, moist, (compact)	87.6	0	18		SS1	
		SILTY CLAY Medium to high plasticity, trace sand, brown, moist, (very stiff)	86.7	1	7		SS2	
			85.7	2	8; 120 kPa; 115 kPa; s=5.8		SS3	18.5
		SHALEY GLACIAL TILL Silty sand, some clay seams of low plasticity, trace fine gravel, sized shale fragments, possible cobbles and boulders, dark grey, wet, (very loose to very dense)	84.8	3	4		SS4	
					Hammer Weight		SS5	
				5	13		SS6	
		With seams of shale fragments below 5.3 m depth.			67		SS7	
				6	6, 27 then 50/125 mm		SS8	
			80.7					
		Auger Refusal at 6.9 m Depth						

LOG OF BOREHOLE LOGS OF BOREHOLES 02.13.2024.GPJ TROW OTTAWA.GDT 05/08/24

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. 32 mm monitoring well installed upon completion
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-22026647-A0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
January 9, 2024	1.8	6.9
April 17, 2024	1.9	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH23-4

Project No: OTT-22026647-A0

Project: Proposed Residential Development

Location: 1770 Heatherington Road, Ottawa, ON

Figure No. 7

Page. 1 of 1

Date Drilled: 'December 1, 2023

Drill Type: CME 45 Track-Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: M.Z. Checked by: I.T.

Split Spoon Sample ⊠ | Auger Sample ◧ | SPT (N) Value ○ | Dynamic Cone Test —— | Shelby Tube ■ | Shear Strength by Vane Test +S

Combustible Vapour Reading □ | Natural Moisture Content × | Atterberg Limits |—○—| | Undrained Triaxial at % Strain at Failure ⊕ | Shear Strength by Penetrometer Test ▲

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth	Standard Penetration Test N Value / Shear Strength kPa	Combustible Vapour Reading (ppm) / Natural Moisture Content % / Atterberg Limits (% Dry Weight)	SAMPLES	Natural Unit Wt. kN/m³
		FILL Silty sand, some crushed gravel (clear stone), brown, moist, (compact)	87.32	0	14		SS1	
			86.6					
		SILTY CLAY Brown, moist to wet, (very stiff)		1	6; 120 kPa		SS2	
				2	3; 150 kPa, s=10.0		SS3	
▽			84.6					
		SILTY CLAY Grey, moist, (stiff)	84.62	3	1		SS4	
				4	72 kPa, s=30.0			
		SHALEY GLACIAL TILL Silty sand, some fine gravel sized shale fragments, some clay of low plasticity, possible cobbles and boulders, dark grey, wet, (very loose)	83.0	5	2		SS5	
			81.2	6				
		Auger Refusal at 6.1 m Depth						

LOG OF BOREHOLE LOGS OF BOREHOLES 02.13.2024.GPJ TROW OTTAWA.GDT 05/08/24

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. 32 mm monitoring well installed upon completion
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-22026647-A0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
January 9, 2024	2.7	6.1
April 17, 2024	2.7	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH23-5

Project No: OTT-22026647-A0

Project: Proposed Residential Development

Location: 1770 Heatherington Road, Ottawa, ON

Figure No. 8

Page. 1 of 1

Date Drilled: 'December 12, 2023

Drill Type: CME 45 Track-Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: M.Z. Checked by: I.T.

Split Spoon Sample ⊠ | Auger Sample ◧ | SPT (N) Value ○ | Dynamic Cone Test —— | Shelby Tube ■ | Shear Strength by Vane Test +S

Combustible Vapour Reading □ | Natural Moisture Content × | Atterberg Limits |—○—| | Undrained Triaxial at % Strain at Failure ⊕ | Shear Strength by Penetrometer Test ▲

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth	Standard Penetration Test N Value (20 40 60 80) / Shear Strength kPa (50 100 150 200)	Combustible Vapour Reading (ppm) (250 500 750) / Natural Moisture Content % Atterberg Limits (% Dry Weight) (20 40 60)	SAMPLES	Natural Unit Wt. kN/m³
		FILL Silty sand and crushed gravel, grey, wet, (dense to very dense)	87.5	0				
				1				
				2	54	×	SS1	
					32	×	SS1A	
			84.5	3				
		FILL ~150mm thick Silty clay, some gravel and sand, dark brown to dark grey, moist	84.3		20	×	SS2	
		SHALEY GLACIAL TILL Silty sand, some fine gravel sized shale fragments, some clay seams, possible cobbles and boulders, dark grey, wet, (loose to compact)		4	5	×	SS3	
				5	23	×	SS4	
			82.0					
		HIGHLY WEATHERED SHALE BEDROCK Gravel sized shale fragments, some sand, dark grey, wet	81.7		50/0mm		SS5	
		Auger Refusal at 5.8 m Depth						

LOG OF BOREHOLE LOGS OF BOREHOLES 02.13.2024.GPJ TROW OTTAWA.GDT 05/08/24

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. Borehole was backfilled upon completion.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-22026647-A0

WATER LEVEL RECORDS		
Date	Water Level (m)	Hole Open To (m)
	3.0	5.8

CORE DRILLING RECORD			
Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH23-6

Project No: OTT-22026647-A0

Project: Proposed Residential Development

Location: 1770 Heatherington Road, Ottawa, ON

Figure No. 9

Page. 1 of 1

Date Drilled: 'November 23, 2023

Drill Type: CME 45 Track-Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: M.Z. Checked by: I.T.

Split Spoon Sample ⊠ | Auger Sample ◧ | SPT (N) Value ○ | Dynamic Cone Test —— | Shelby Tube ■ | Shear Strength by Vane Test +S

Combustible Vapour Reading □ | Natural Moisture Content × | Atterberg Limits ⊢○⊣ | Undrained Triaxial at % Strain at Failure ⊕ | Shear Strength by Penetrometer Test ▲

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth	Standard Penetration Test N Value / Shear Strength kPa	Combustible Vapour Reading (ppm) / Natural Moisture Content % / Atterberg Limits (% Dry Weight)	SAMPLES	Natural Unit Wt. kN/m³
		FILL Silty sand, some gravel, brown, damp, (very dense)	87.24	0	68	×	SS1	
		FILL~200 mm thick Silty clay, brown to grey, moist	86.5					
		SILTY CLAY Brown, moist, (very stiff)	86.3	1	14	×	SS2	17.9
				2	6	×	SS3	16.5
					130 kPa s=9.0			
		SHALEY GLACIAL TILL Silty sand some fine gravel sized shale fragments, some clay, possible cobbles and boulders, dark grey, wet, (very loose to compact)	84.4	3	8	×	SS4	
				4	3	×	SS5	
				5	9	×	SS6	
					21	×	SS7	
				6	50/75mm	×	SS8	
		SHALE BEDROCK With 25 mm thick clay seam at 7.6 m depth, dark grey to black, (fair to good quality)	81.0	7			RUN 1	
				8			RUN 2	
			77.9	9				
		Borehole Terminated at 9.3 m Depth						

LOG OF BOREHOLE LOGS OF BOREHOLES 02.13.2024.GPJ TROW OTTAWA.GDT 05/08/24

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. Borehole was backfilled upon completion.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-22026647-A0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %
1	6.2 - 7.6	97	83
2	7.6 - 9.3	91	58

Log of Borehole BH23-7

Project No: OTT-22026647-A0

Project: Proposed Residential Development

Location: 1770 Heatherington Road, Ottawa, ON

Figure No. 10

Page. 1 of 1

Date Drilled: 'December 1, 2023

Drill Type: CME 45 Track-Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: M.Z. Checked by: I.T.

Split Spoon Sample ⊠ | Auger Sample ◧ | SPT (N) Value ○ | Dynamic Cone Test —— | Shelby Tube ■ | Shear Strength by Vane Test +S

Combustible Vapour Reading □ | Natural Moisture Content × | Atterberg Limits |—○—| | Undrained Triaxial at % Strain at Failure ⊕ | Shear Strength by Penetrometer Test ▲

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth	Standard Penetration Test N Value / Shear Strength kPa	Combustible Vapour Reading (ppm) / Natural Moisture Content % / Atterberg Limits (% Dry Weight)	SAMPLES	Natural Unit Wt. kN/m³
		TOPSOIL ~ 300 mm thick	87.07	0	9		SS1	
		FILL Silty sand, some gravel, brown, moist, (loose)	86.8					
		FILL Silty clay, trace sand, brown to grey, moist, (loose)	86.4	1	7		SS2	
		ORGANIC CLAYEY SILT~ 75 mm thick Black, moist	85.6					
		SILTY CLAY Brown, moist, (very stiff)	85.5	2	4		SS3	
					140 kPa s=5.6			
		SILTY CLAY High plasticity, trace sand, grey, wet, (firm)	84.3	3	2		SS4	
				4	48 kPa s=6.7			
		SHALEY GLACIAL TILL Sandy silt with some clay, trace fine gravel sized shale fragments to silty clay of low plasticity, sandy, trace fine gravel sized shale fragments, possible cobbles and boulders, dark grey, wet, (loose to firm)	82.8	5	4		SS5	
		Auger Refusal at 5.6 m Depth	81.5					

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. Borehole was backfilled upon completion.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-22026647-A0

WATER LEVEL RECORDS		
Date	Water Level (m)	Hole Open To (m)
	Dry	5.6

CORE DRILLING RECORD			
Run No.	Depth (m)	% Rec.	RQD %

LOG OF BOREHOLE LOGS OF BOREHOLES 02.13.2024.GPJ TROW OTTAWA.GDT 05/08/24

Log of Borehole BH23-8

Project No: OTT-22026647-A0

Project: Proposed Residential Development

Location: 1770 Heatherington Road, Ottawa, ON

Figure No. 11

Page. 1 of 1

Date Drilled: 'November 21, 2023

Drill Type: CME 45 Track-Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: M.Z. Checked by: I.T.

Split Spoon Sample ⊠ | Auger Sample ◧ | SPT (N) Value ○ | Dynamic Cone Test —— | Shelby Tube ■ | Shear Strength by Vane Test +S

Combustible Vapour Reading □ | Natural Moisture Content × | Atterberg Limits |—○—| | Undrained Triaxial at % Strain at Failure ⊕ | Shear Strength by Penetrometer Test ▲

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth	Standard Penetration Test N Value / Shear Strength kPa	Combustible Vapour Reading (ppm) / Natural Moisture Content % / Atterberg Limits (% Dry Weight)	SAMPLES	Natural Unit Wt. kN/m³
		FILL Silty sand, some gravel, brown to black, moist, (loose)	87.15	0	9	×	SS1	
			86.5					
		ORGANIC CLAYEY SILT ~ 150 mm thick Dark brown, moist	86.3					
		SILTY CLAY Some sand, brown, moist, (very stiff)	86.05	1	14	×	SS2	18.2
				2	6	×	SS3	16.9
					150 kPa + s=7.5			
			84.4					
		SILTY CLAY Grey, moist, (soft)	83.9	3	3	×	SS4	
		SHALEY GLACIAL TILL Sandy silt with some clay, trace fine gravel sized shale fragments to silty clay, sandy, trace fine gravel sized shale fragments, possible cobbles and boulders, dark grey, wet, (very loose to loose)			Hammer Weight	×	SS5	
				5	5	×	SS6	
			81.6					
		Auger Refusal at 5.6 m Depth						

LOG OF BOREHOLE LOGS OF BOREHOLES 02.13.2024.GPJ TROW OTTAWA.GDT 05/08/24

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. 50 mm monitoring well installed upon completion
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-22026647-A0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
January 9, 2024	1.3	5.6
April 17, 2024	1.1	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH23-9

Project No: OTT-22026647-A0

Project: Proposed Residential Development

Location: 1770 Heatherington Road, Ottawa, ON

Figure No. 12

Page. 1 of 1

Date Drilled: 'November 21, 2023

Drill Type: CME 45 Track-Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: M.Z. Checked by: I.T.

Split Spoon Sample ⊠ | Auger Sample ◧ | SPT (N) Value ○ | Dynamic Cone Test —— | Shelby Tube ■ | Shear Strength by Vane Test +S

Combustible Vapour Reading □ | Natural Moisture Content × | Atterberg Limits —○— | Undrained Triaxial at % Strain at Failure ⊕ | Shear Strength by Penetrometer Test ▲

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth
		FILL ~200 mm thick	86.49	0
		Silty sand, some gravel, brown, moist	86.2	
		ORGANIC CLAYEY SILT ~ 100 mm thick	86.1	
		Dark brown, moist		1
		SILTY CLAY		
		High plasticity, some sand, brown, moist, (very stiff)		
			84.4	2
		SILTY CLAY		
		Grey, moist, (firm)		3
			82.7	4
		SHALEY GLACIAL TILL		
		Silty sand, gravelly (fine shale fragments), trace clay seams, possible cobbles and boulders, moist to wet, (very loose to compact)		5
			80.3	6
		SHALE BEDROCK		
		Dark grey to black, (poor to fair quality)		7
				8
			76.6	9
		Borehole Terminated at 9.9 m Depth		

Standard Penetration Test N Value: 20 40 60 80

Shear Strength kPa: 50 100 150 200

Combustible Vapour Reading (ppm): 250 500 750

Natural Moisture Content % Atterberg Limits (% Dry Weight): 20 40 60

SAMPLES | Natural Unit Wt. kN/m³

12 — SS1

9 — SS2 — 18.2

120 kPa, s=9.6

2 — SS3

38 kPa, s=10.7

2 — SS4

24 — SS5

35/50mm — SS6

RUN 1

RUN 2

RUN 3

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. Borehole was backfilled upon completion.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-22026647-A0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %
1	6.2 - 7	100	33
2	7 - 8.4	100	48
3	8.4 - 9.9	100	70

LOG OF BOREHOLE LOGS OF BOREHOLES 02.13.2024.GPJ TROW OTTAWA.GDT 05/08/24

Log of Borehole BH24-10

Project No: OTT-22026647-A0

Project: Proposed Residential Development

Location: 1770 Heatherington Road, Ottawa, ON

Figure No. 13

Page. 1 of 1

Date Drilled: 'March 26, 2024

Drill Type: CME 45 Track-Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: M.Z. Checked by: I.T.

Split Spoon Sample ⊠ | Auger Sample ◧ | SPT (N) Value ○ | Dynamic Cone Test —— | Shelby Tube ■ | Shear Strength by Vane Test +S

Combustible Vapour Reading □ | Natural Moisture Content × | Atterberg Limits ⊢○ | Undrained Triaxial at % Strain at Failure ⊕ | Shear Strength by Penetrometer Test ▲

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth	Standard Penetration Test N Value / Shear Strength kPa	Combustible Vapour Reading (ppm) / Natural Moisture Content % / Atterberg Limits (% Dry Weight)	SAMPLES	Natural Unit Wt. kN/m³
		TOPSOIL ~ 50 mm thick	87.69	0				
		FILL AND RECLAIMED ASPHALT PAVEMENT (RAP) Mixture of silty sand, some gravel and RAP, brown, moist, (compact)	87.6 86.9					
		ORGANIC CLAYEY SILT ~ 125 mm thick Dark grey brown, moist	86.8 86.39	1	16		SS1	
		SILTY CLAY Brown, moist, (very stiff)			11		SS2	
				2	8		SS3	
			85.4		120 kPa s=4			
		SILTY CLAY High plasticity, trace gravel and sand, grey, wet, (stiff to very stiff)			4		SS4	
				3	100 kPa s=10			
			84.0					
		SHALEY GLACIAL TILL Silty sand, some fine gravel sized shale fragments, clay seams, possible cobbles and boulders, grey, wet, (compact to dense)		4	20		SS5	
				5	19		SS6	
		With seams of shale fragments below 6.1m depth.		6	36, then 50 for 125mm		SS7	
			81.1					
		Casing Refusal at 6.6 m Depth						

LOG OF BOREHOLE LOGS OF BOREHOLES 02.13.2024.GPJ TROW OTTAWA.GDT 05/08/24

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. 19mm standpipe installed upon completion
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-22026647-A0

WATER LEVEL RECORDS		
Date	Water Level (m)	Hole Open To (m)
April 17, 2024	1.3	

CORE DRILLING RECORD			
Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH24-12

Project No: OTT-22026647-A0

Project: Proposed Residential Development

Location: 1770 Heatherington Road, Ottawa, ON

Figure No. 14

Page. 1 of 1

Date Drilled: 'March 25, 2024

Drill Type: CME 45 Track-Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: A.N Checked by: I.T.

Split Spoon Sample
Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Shear Strength by Vane Test (S)

Combustible Vapour Reading
Natural Moisture Content
Atterberg Limits
Undrained Triaxial at % Strain at Failure
Shear Strength by Penetrometer Test

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth	Standard Penetration Test N Value / Shear Strength kPa	Combustible Vapour Reading (ppm) / Natural Moisture Content % / Atterberg Limits (% Dry Weight)	SAMPLES	Natural Unit Wt. kN/m³
		TOPSOIL ~ 50 mm thick	87.49	0	17		SS1	
		87.4						
		FILL Mixture of silty sand and topsoil, brown and black, moist, (compact)						
			86.5	1	11		SS2	
		SILTY CLAY Brown, moist to wet, (stiff)						
				2	5		SS3	
					90 kPa s=9.0			
			85.2					
		SILTY CLAY Medium plasticity, some sand, grey, wet, (stiff)			1		SS4	
					72 kPa s=8.6			
				3	Hammer Weight		SS5	
					72 kPa s=30			
			83.5	4	3		SS6	
		SHALEY GLACIAL TILL Silty sand, some clay seams of low plasticity, trace fine gravel sized shale fragments, possible cobbles and boulders, dark grey, wet, (very loose to very dense)			5		SS7	
				5				
				6				
		With seams of shale fragments below 6.1 m depth.			95		SS8	
			80.9					
		Casing Refusal at 6.6 m Depth						

LOG OF BOREHOLE LOGS OF BOREHOLES 02.13.2024.GPJ TROW OTTAWA.GDT 05/08/24

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. Borehole was backfilled upon completion.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-22026647-A0

WATER LEVEL RECORDS		
Date	Water Level (m)	Hole Open To (m)

CORE DRILLING RECORD			
Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH24-13

Project No: OTT-22026647-A0

Project: Proposed Residential Development

Location: 1770 Heatherington Road, Ottawa, ON

Figure No. 15

Page. 1 of 1

Date Drilled: 'March 25, 2024

Drill Type: CME 45 Track-Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: A.N Checked by: I.T.

Split Spoon Sample ⊠
Auger Sample ◧
SPT (N) Value ○
Dynamic Cone Test ——
Shelby Tube ■
Shear Strength by Vane Test +S

Combustible Vapour Reading □
Natural Moisture Content ×
Atterberg Limits I—○
Undrained Triaxial at % Strain at Failure ⊕
Shear Strength by Penetrometer Test ▲

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth	Standard Penetration Test N Value / Shear Strength kPa	Combustible Vapour Reading (ppm) / Natural Moisture Content % / Atterberg Limits (% Dry Weight)	SAMPLES	Natural Unit Wt. kN/m³
		FILL Silty sand, some gravel, possible rootlets, cobbles and boulders, brown, moist, (compact)	86.93	0	24	×	SS1	
		SILTY CLAY Trace to some sand seams, brown, moist, (very stiff)	86.0	1	7	×	SS2	
				2	3	×	SS3	
					120 kPa			
		SILTY CLAY Silty clay of high plasticity, trace sand, grey, wet, (stiff)	84.6	2	2	×	SS4	
				3	67 kPa, s=14			
					Hammer Weight	I—○ ×	SS5	
					91 kPa, s=19			
					Hammer Weight	×	SS6	
		SHALEY GLACIAL TILL Silty sand, some fine gravel sized shale fragments, clay seams of low plasticity, possible cobbles and boulders, dark grey, wet, (loose to dense)	82.7	5	7	× ○	SS7	
				6	36	×	SS8	
			80.0					
		Casing Refusal at 6.9 m Depth						

LOG OF BOREHOLE LOGS OF BOREHOLES 02.13.2024.GPJ TROW OTTAWA.GDT 05/08/24

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. Borehole was backfilled upon completion.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-22026647-A0

WATER LEVEL RECORDS		
Date	Water Level (m)	Hole Open To (m)

CORE DRILLING RECORD			
Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH24-14

Project No: OTT-22026647-A0

Project: Proposed Residential Development

Location: 1770 Heatherington Road, Ottawa, ON

Figure No. 16

Page. 1 of 1

Date Drilled: 'March 24, 2024

Drill Type: CME 45 Track-Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: A.N Checked by: I.T.

Split Spoon Sample ⊠ | Auger Sample ◧ | SPT (N) Value ○ | Dynamic Cone Test —— | Shelby Tube ■ | Shear Strength by Vane Test +S

Combustible Vapour Reading □ | Natural Moisture Content × | Atterberg Limits ⊢○ | Undrained Triaxial at % Strain at Failure ⊕ | Shear Strength by Penetrometer Test ▲

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth	Standard Penetration Test N Value (20 40 60 80) / Shear Strength kPa (50 100 150 200)	Combustible Vapour Reading (ppm) (250 500 750) / Natural Moisture Content % Atterberg Limits (% Dry Weight) (20 40 60)	SAMPLES	Natural Unit Wt. kN/m³
		FILL Mixture of silty sand and silty clay, some topsoil inclusions, dark brown to dark grey, moist, (compact)	86.69	0	15	×	SS1	
		SILTY CLAY Brown, moist, (stiff)	85.8	1	10	×	SS2	
				2	2	×	SS3	
		SILTY CLAY Silty clay of meduim plasticity, trace sand, grey, wet, (firm)	84.5	2	96 kPa s=13.3 Hammer Weight	×	SS4	
				3	43 kPa s=4.5 Hammer Weight	⊢○ ×	SS5	
					34 kPa s=14			
		SHALEY GLACIAL TILL Silty sand, some fine gravel sized shale fragments and clay seams, possible cobbles and boulders, dark grey, wet, (compact to dense)	82.7	4	10	×	SS6	
				5	34	×	SS7	
				6	40, then 50 for 25mm	×	SS8	
		Casing Refusal at 6.3 m Depth	80.4					

LOG OF BOREHOLE LOGS OF BOREHOLES 02.13.2024.GPJ TROW OTTAWA.GDT 05/08/24

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. Borehole was backfilled upon completion.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-22026647-A0

WATER LEVEL RECORDS		
Date	Water Level (m)	Hole Open To (m)

CORE DRILLING RECORD			
Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH24-15

Project No: OTT-22026647-A0

Project: Proposed Residential Development

Location: 1770 Heatherington Road, Ottawa, ON

Figure No. 17

Page. 1 of 1

Date Drilled: 'March 25, 2024

Drill Type: CME 45 Track-Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: A.N Checked by: I.T.

Split Spoon Sample
Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Shear Strength by Vane Test

Combustible Vapour Reading
Natural Moisture Content
Atterberg Limits
Undrained Triaxial at % Strain at Failure
Shear Strength by Penetrometer Test

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth	Standard Penetration Test N Value / Shear Strength kPa	Combustible Vapour Reading (ppm) / Natural Moisture Content % / Atterberg Limits (% Dry Weight)	SAMPLES	Natural Unit Wt. kN/m³
		TOPSOIL ~ 100 mm thick	87.22	0	24		SS1	
		FILL Silty sand, some gravel, topsoil inclusions, brown, moist, (compact)	87.1					
		SILTY CLAY Brown, moist, (stiff to very stiff)	86.3	1	7		SS2	
				2	3		SS3	
					100 kPa s=10.0			
		SILTY CLAY Silty clay of medium to high plasticity, trace gravel, trace to some sand, (sand seams), grey, wet, (firm to stiff)	84.9		1		SS4	
				3	29 kPa s=12.0			
					Hammer Weight		SS5	
					77 kPa s=32.0			
				4	Hammer Weight		SS6	
		SHALEY GLACIAL TILL Silty sand, some fine gravel sized shale fragments, and clay, possible cobbles and boulders, dark grey, (stiff)	82.7	5	8		SS7	
		Casing Refusal at 5.9 m Depth	81.3					

LOG OF BOREHOLE LOGS OF BOREHOLES 02.13.2024.GPJ TROW OTTAWA.GDT 05/08/24

NOTES:

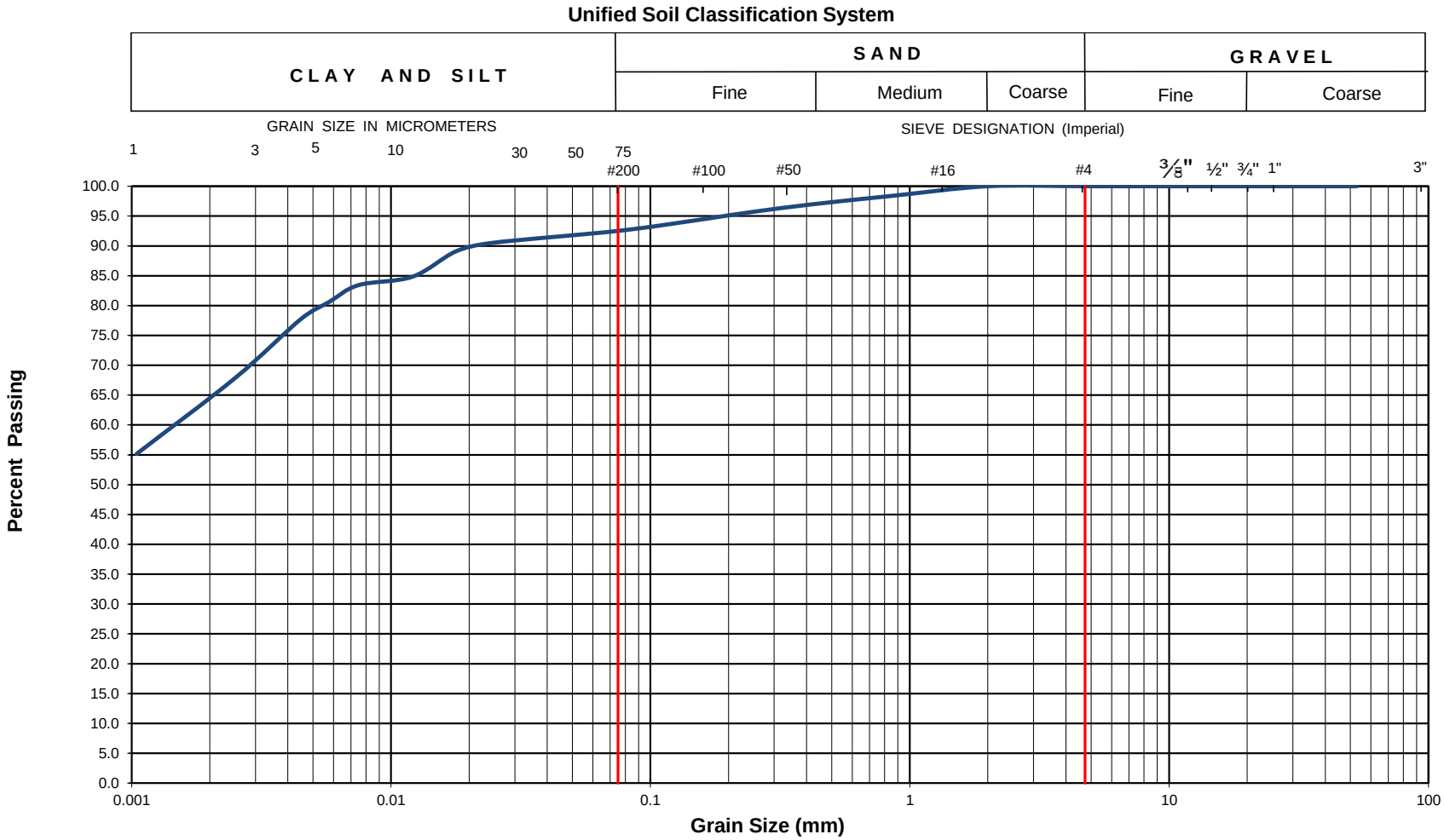
1. Borehole data requires interpretation by EXP before use by others
2. Borehole was backfilled upon completion.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-22026647-A0

WATER LEVEL RECORDS		
Date	Water Level (m)	Hole Open To (m)

CORE DRILLING RECORD			
Run No.	Depth (m)	% Rec.	RQD %

EXP Services Inc.
100-2650 Queensview Drive
Ottawa, ON K2B 8H6

Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	**OTT-22026647-A0**	**Project Name :**	**Proposed Residental Development**						
Client :	**City of Ottawa**	**Project Location :**	**1770 Heatherington Road, Ottawa, ON**						
Date Sampled :	**November 23, 2023**	**Borehole No:**	**BH23-3**	**Sample No.:**	**SS3**	**Depth (m) :**	**1.5-2.1**		
Sample Description :		**% Silt and Clay**	**93**	**% Sand**	**7**	**% Gravel**	**0**	**Figure :**	**18**
Sample Description :	**Silty Clay of Medium to High Plasticity (CI-CH) - Trace Sand**								

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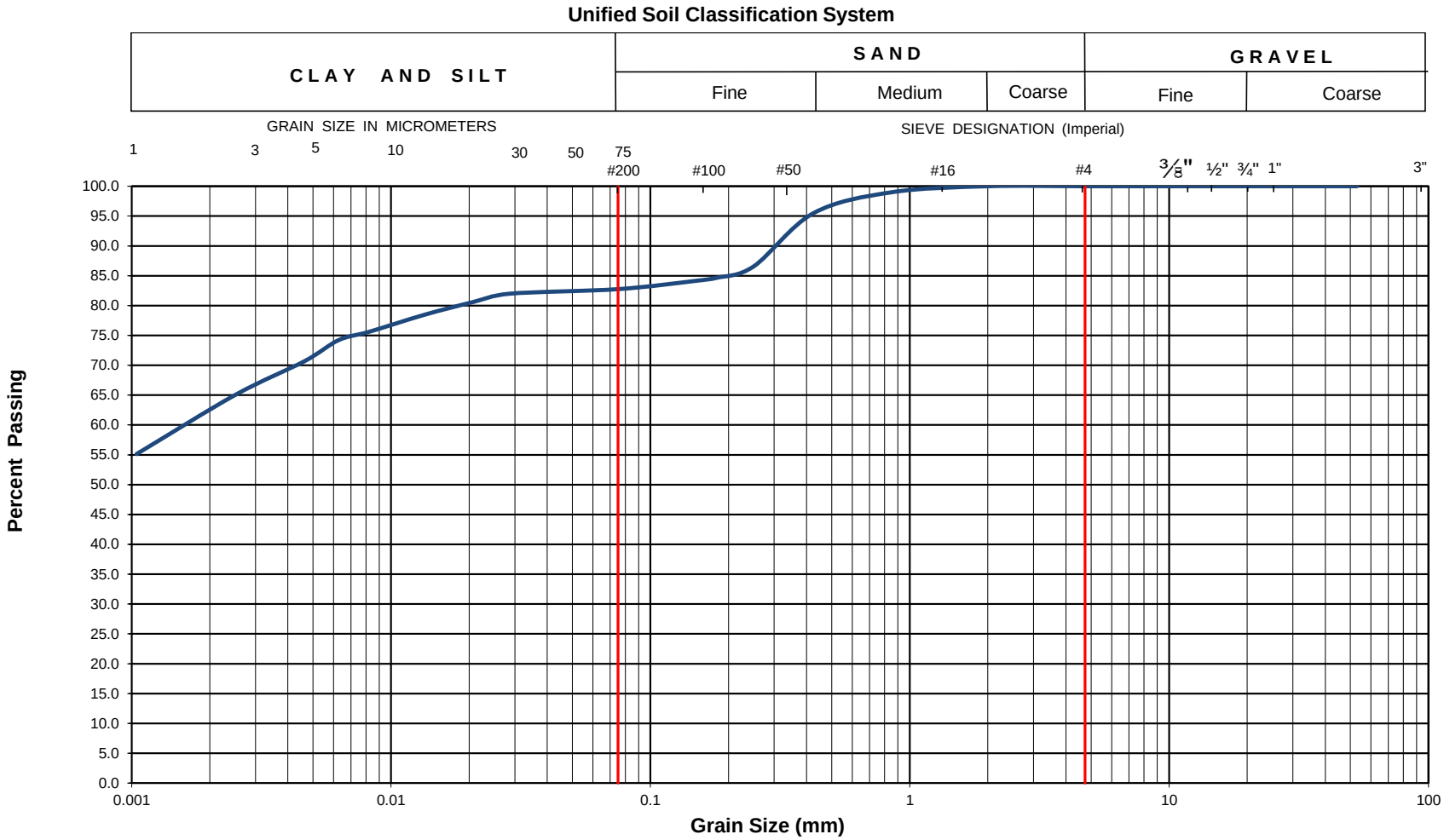
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	**OTT-22026647-A0**	**Project Name :**	**Proposed Residental Development**						
Client :	**City of Ottawa**	**Project Location :**	**1770 Heatherington Road, Ottawa, ON**						
Date Sampled :	**November 21, 2023**	**Borehole No:**	**BH23-9**	**Sample No.:**	**SS2**			**Depth (m) :**	**0.8-1.4**
Sample Description :		**% Silt and Clay**	**83**	**% Sand**	**17**	**% Gravel**	**0**	**Figure :**	**19**
Sample Description :		**Silty Clay of High Plasticity (CH) - Some Sand**							

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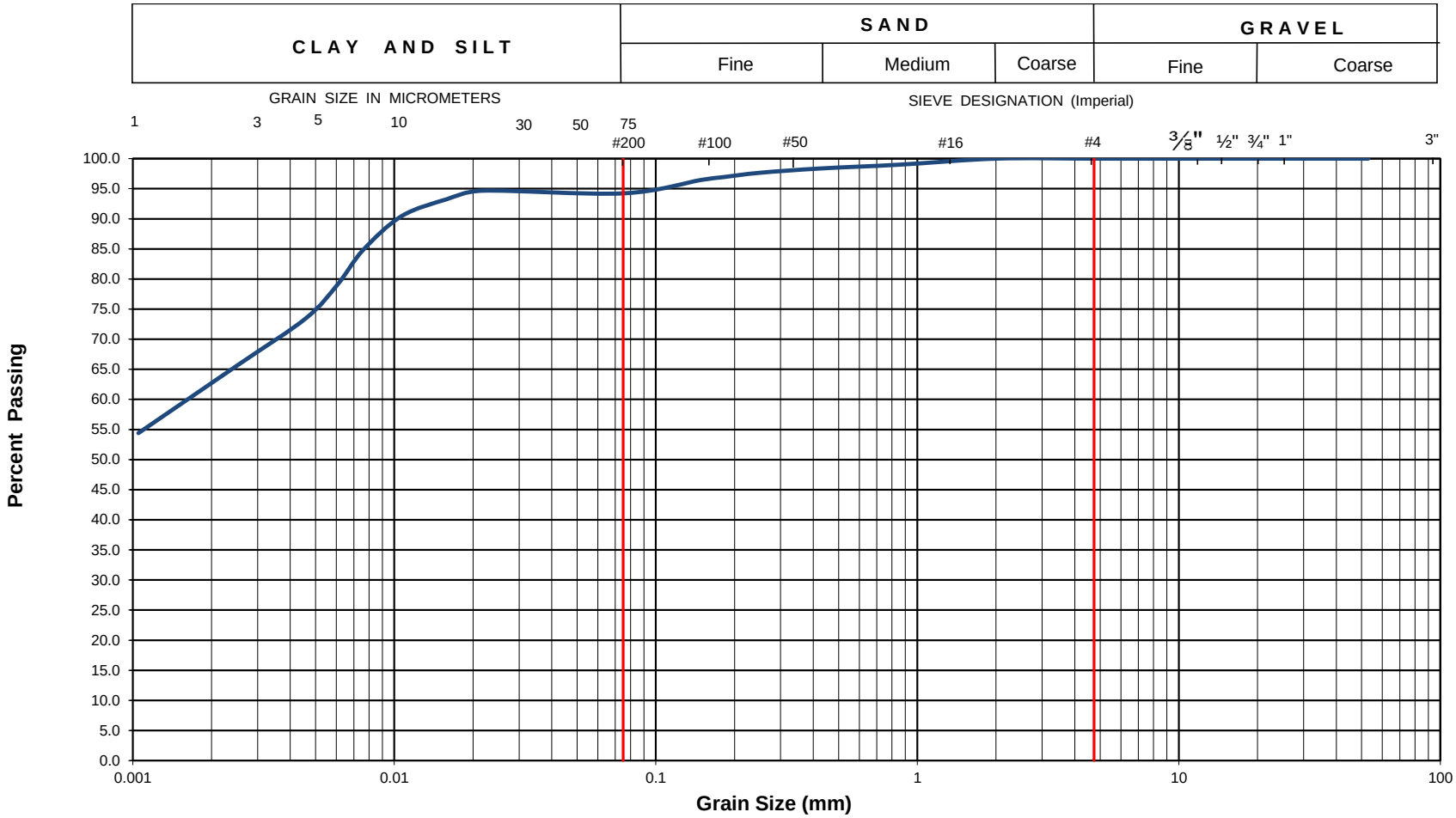
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422

Unified Soil Classification System



EXP Project No.:	**OTT-22026647-A0**	**Project Name :**	**Proposed Residental Development**						
Client :	**City of Ottawa**	**Project Location :**	**1770 Heatherington Road, Ottawa, ON**						
Date Sampled :	**November 30, 2023**	**Borehole No:**	**BH23-1**	**Sample No.:**	**SS4**	**Depth (m) :**	**3.4-3.7**		
Sample Description :		**% Silt and Clay**	**94**	**% Sand**	**6**	**% Gravel**	**0**	**Figure :**	**20**
Sample Description :		**Silty Clay of Medium Plasticity (CI) - Trace Sand**							

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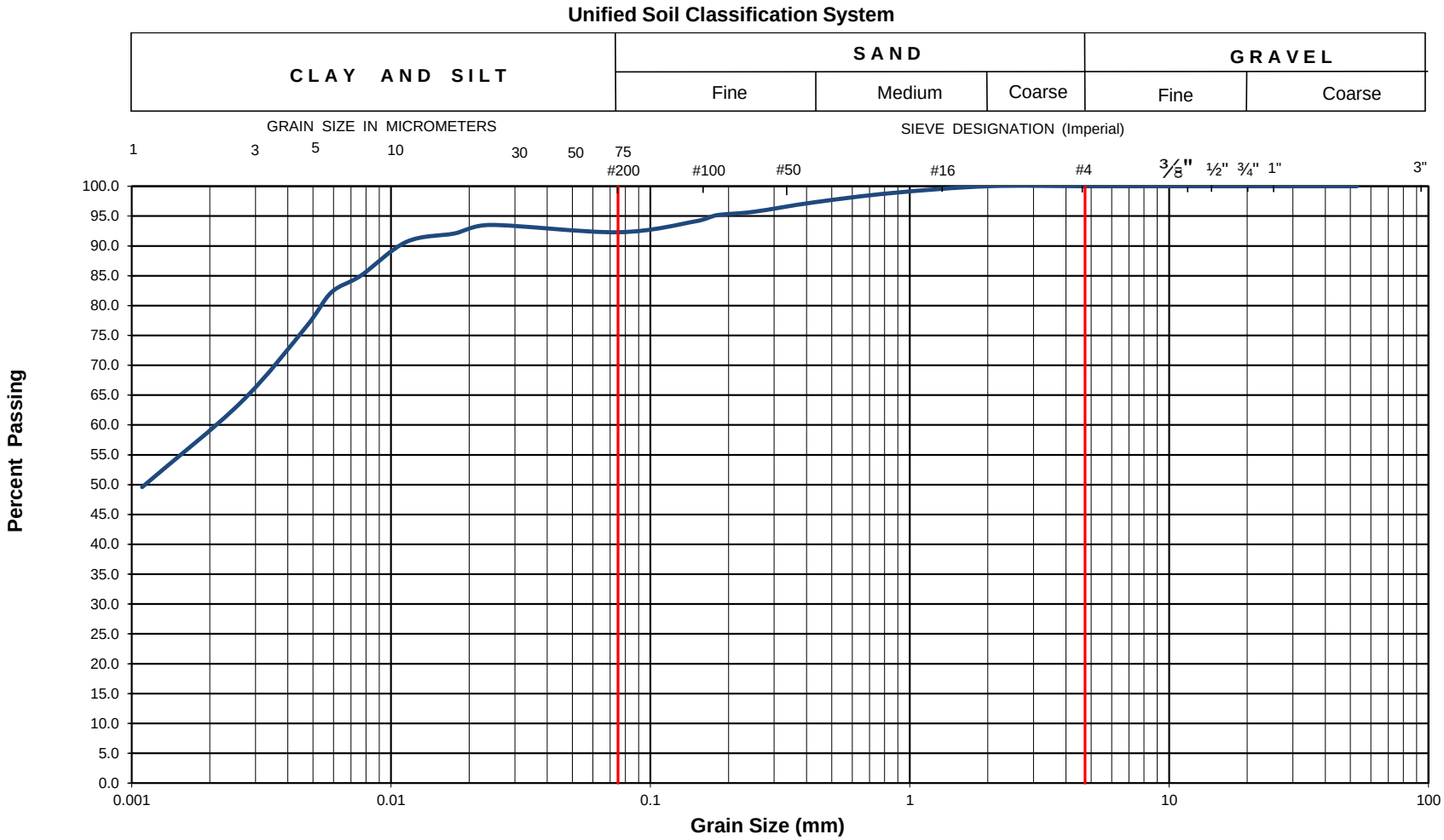
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	**OTT-22026647-A0**	**Project Name :**	**Proposed Residental Development**						
Client :	**City of Ottawa**	**Project Location :**	**1770 Heatherington Road, Ottawa, ON**						
Date Sampled :	**December 1, 2023**	**Borehole No:**	**BH23-7**	**Sample No.:**	**SS4**	**Depth (m) :**	**3.0-3.6**		
Sample Description :		**% Silt and Clay**	**92**	**% Sand**	**8**	**% Gravel**	**0**	**Figure :**	**21**
Sample Description :		**Silty Clay of High Plasticity (CH) - Trace Sand**							

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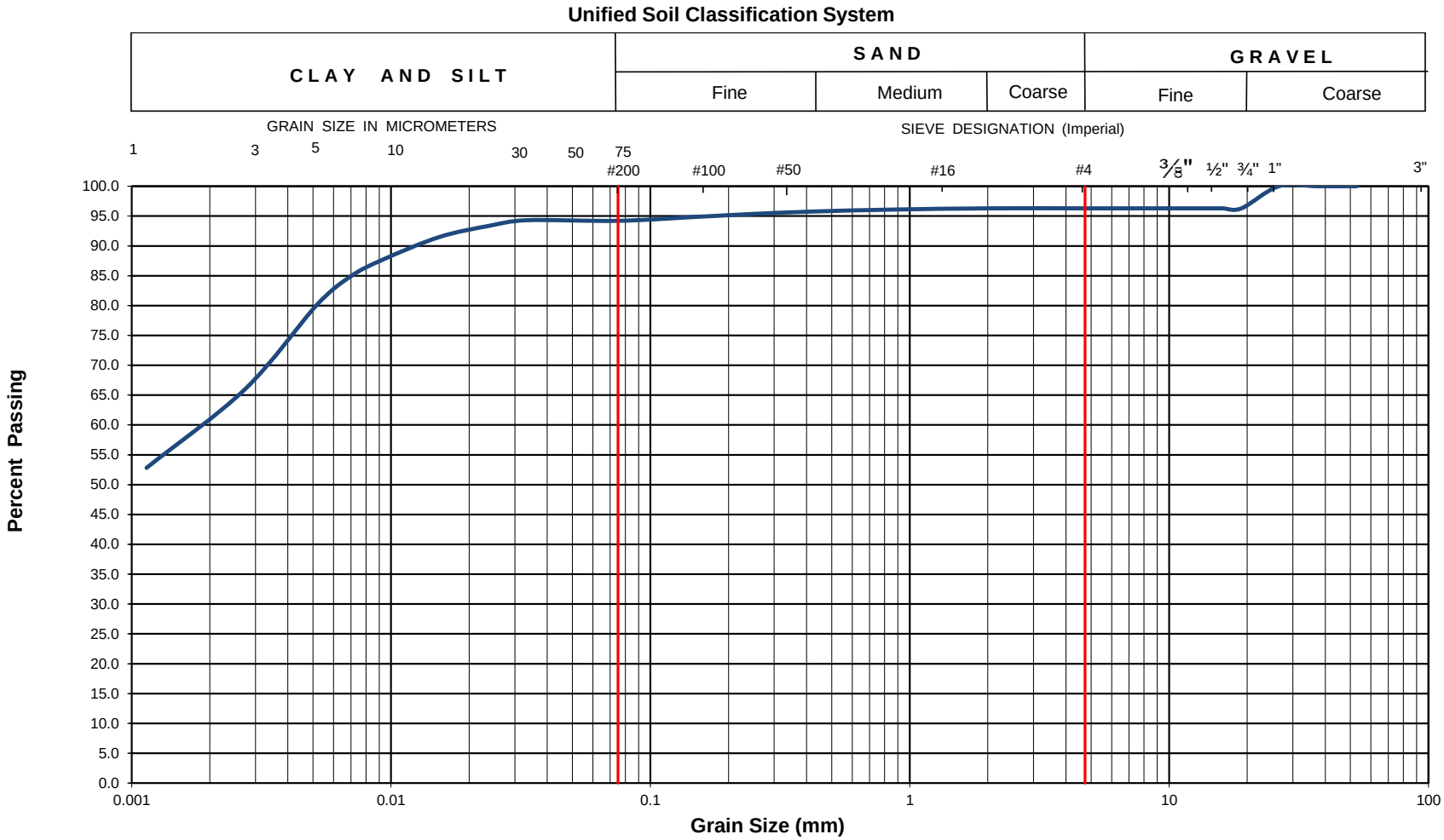
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	**OTT-22026647-A0**	**Project Name :**	**Proposed Residental Development**						
Client :	**City of Ottawa**	**Project Location :**	**1770 Heatherington Road, Ottawa, ON**						
Date Sampled :	**March 26, 2024**	**Borehole No:**	**BH24-10**	**Sample No.:**	**SS4**	**Depth (m) :**	**2.3-2.9**		
Sample Description :		**% Silt and Clay**	**94**	**% Sand**	**2**	**% Gravel**	**4**	**Figure :**	**22**
Sample Description :	**Silty Clay of High Plasticity (CH) -Trace Gravel and Sand**								

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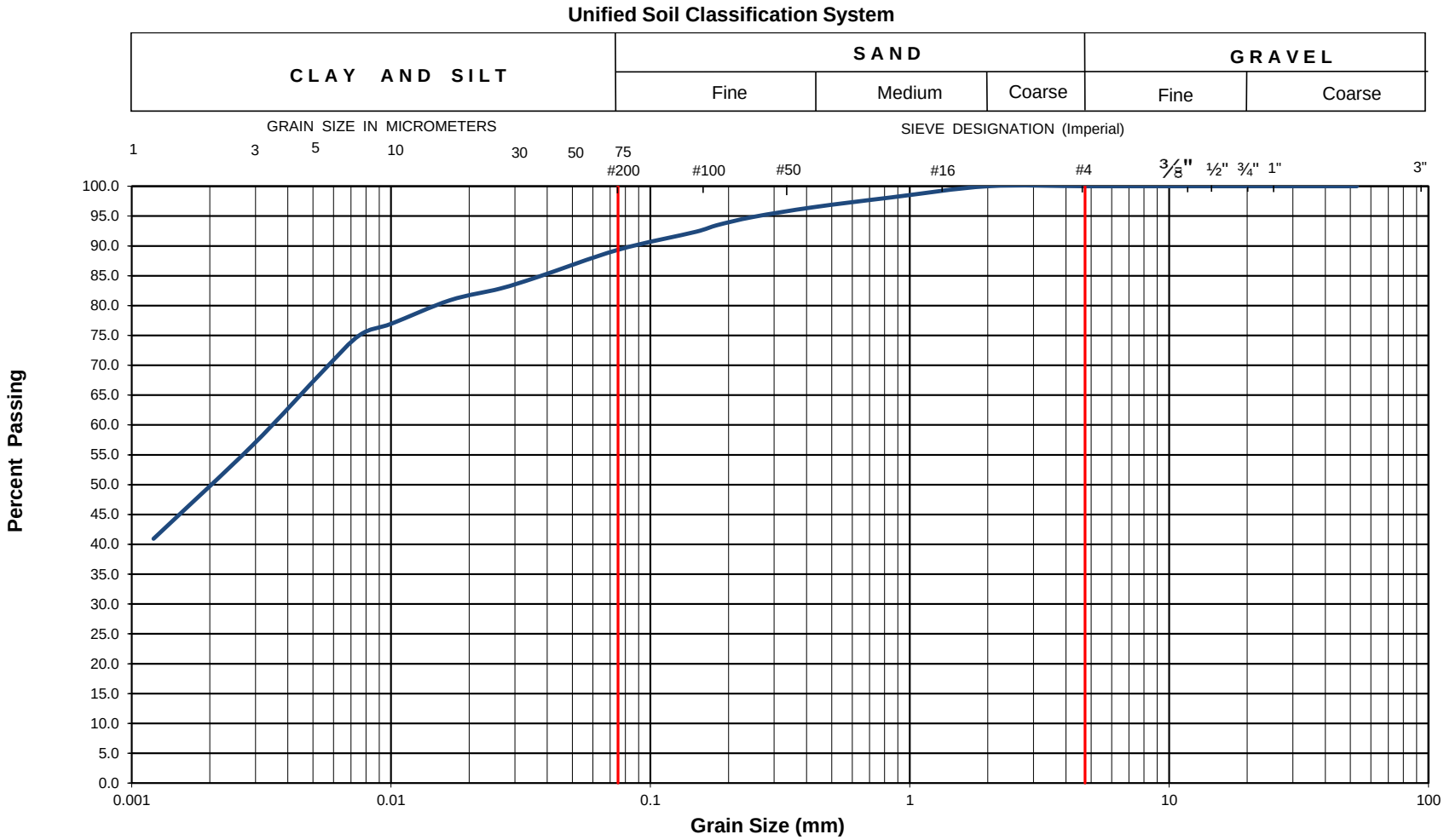
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	**OTT-22026647-A0**	**Project Name :**	**Proposed Residental Development**						
Client :	**City of Ottawa**	**Project Location :**	**1770 Heatherington Road, Ottawa, ON**						
Date Sampled :	**March 25, 2024**	**Borehole No:**	**BH24-12**	**Sample No.:**	**SS5**	**Depth (m) :**	**3.0-3.5**		
Sample Description :		**% Silt and Clay**	**89**	**% Sand**	**11**	**% Gravel**	**0**	**Figure :**	**23**
Sample Description :		**Silty Clay of Medium Plasticity (CI) - Some Sand**							

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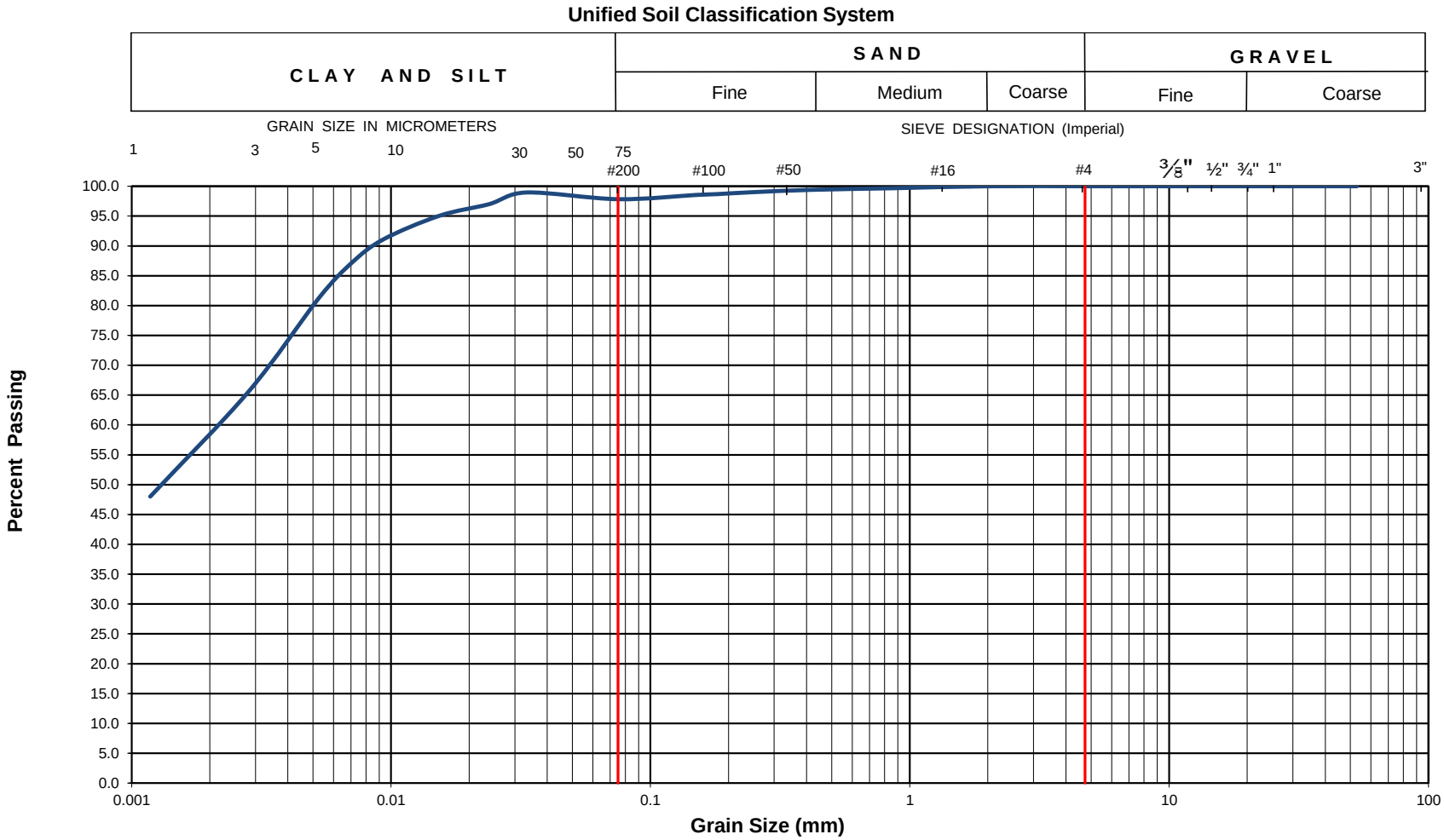
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	**OTT-22026647-A0**	**Project Name :**	**Proposed Residental Development**						
Client :	**City of Ottawa**	**Project Location :**	**1770 Heatherington Road, Ottawa, ON**						
Date Sampled :	**March 25, 2024**	**Borehole No:**	**BH24-13**	**Sample No.:**	**SS5**	**Depth (m) :**	**3.0-3.5**		
Sample Description :		**% Silt and Clay**	**98**	**% Sand**	**2**	**% Gravel**	**0**	**Figure :**	**24**
Sample Description :		**Silty Clay of High Plasticity (CH) -Trace Sand**							

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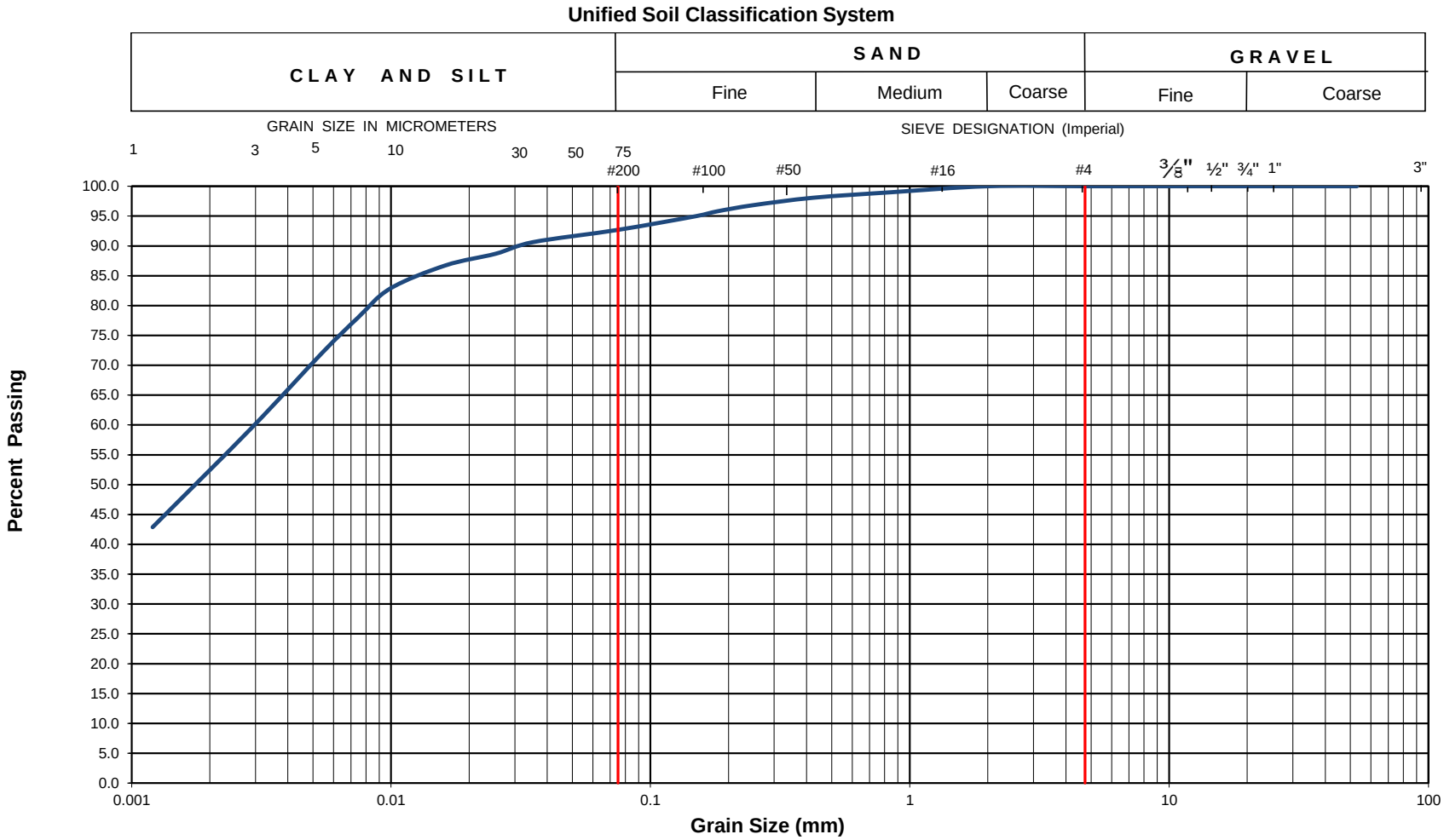
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	**OTT-22026647-A0**	**Project Name :**	**Proposed Residental Development**						
Client :	**City of Ottawa**	**Project Location :**	**1770 Heatherington Road, Ottawa, ON**						
Date Sampled :	**March 25, 2024**	**Borehole No:**	**BH24-14**	**Sample No.:**	**SS5**	**Depth (m) :**	**3.0-3.5**		
Sample Description :		**% Silt and Clay**	**93**	**% Sand**	**7**	**% Gravel**	**0**	**Figure :**	**25**
Sample Description :		**Silty Clay of Medium Plasticity (CI) - Trace Sand**							

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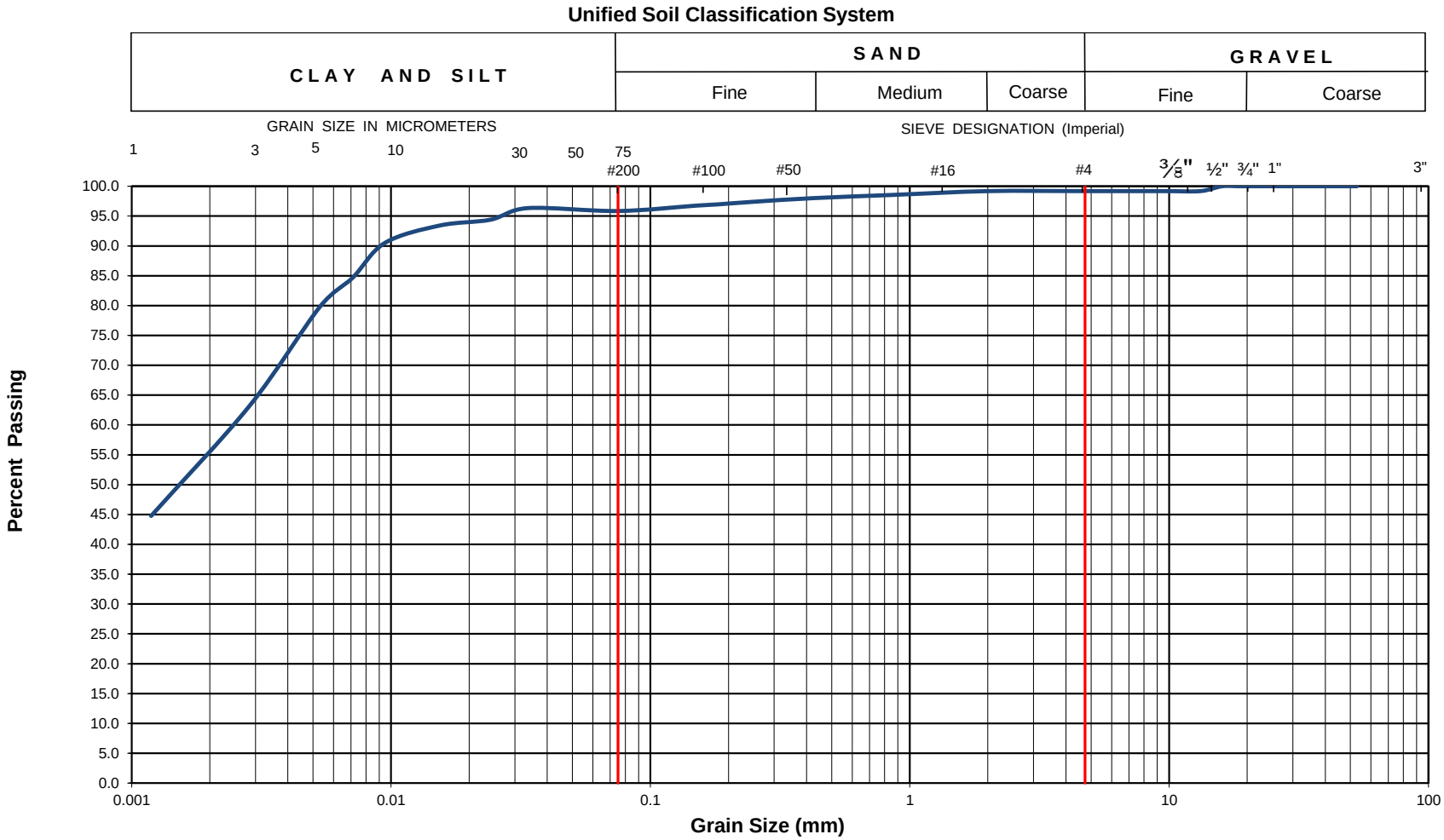
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	**OTT-22026647-A0**	**Project Name :**	**Proposed Residental Development**						
Client :	**City of Ottawa**	**Project Location :**	**1770 Heatherington Road, Ottawa, ON**						
Date Sampled :	**March 25, 2024**	**Borehole No:**	**BH24-15**	**Sample No.:**	**SS5**	**Depth (m) :**	**3.0-3.5**		
Sample Description :		**% Silt and Clay**	**96**	**% Sand**	**3**	**% Gravel**	**1**	**Figure :**	**26**
Sample Description :	**Silty Clay of Medium to High Plasticity (CI-CH) - Trace Gravel and Sand**								

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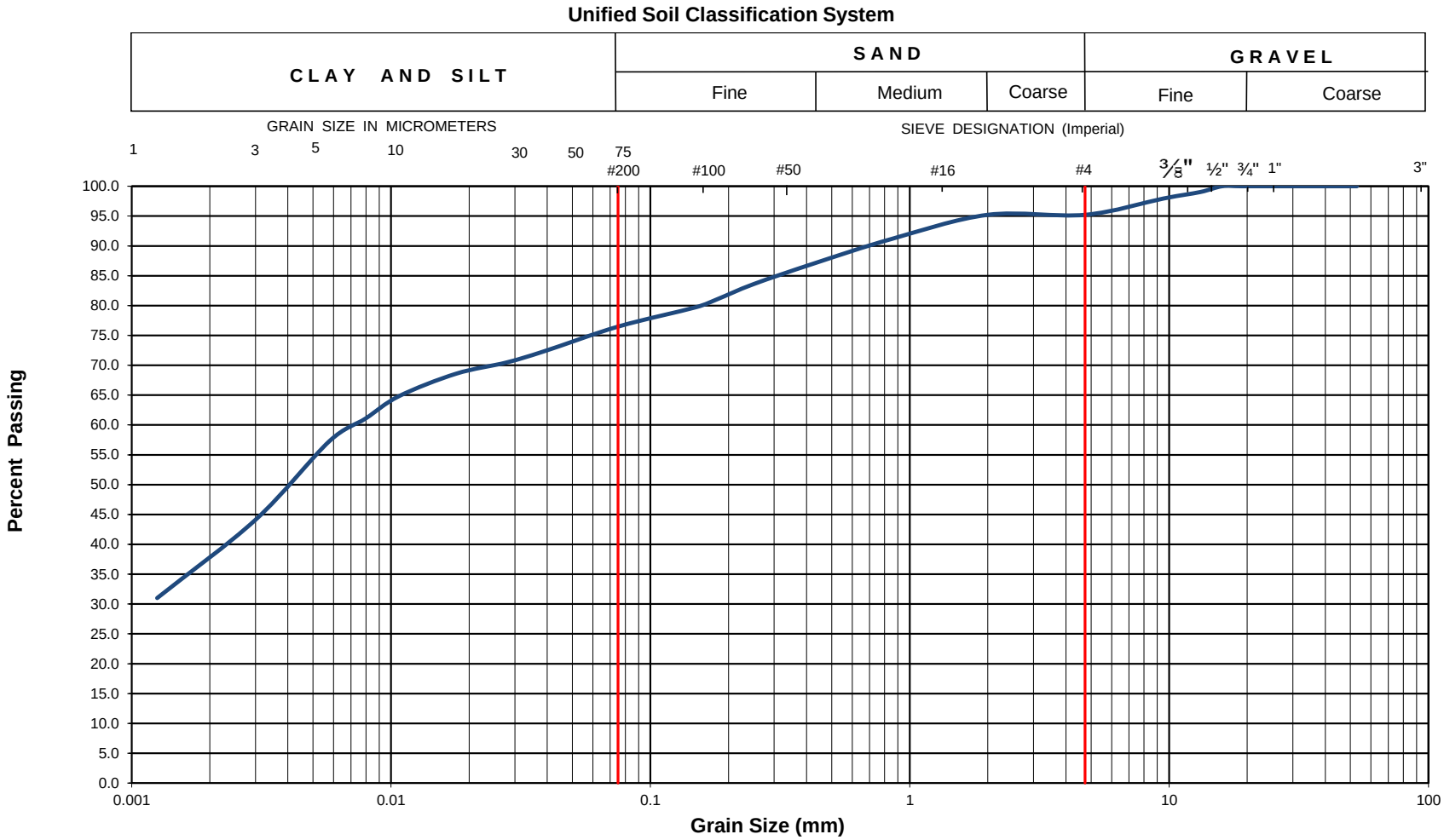
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	**OTT-22026647-A0**	**Project Name :**	**Proposed Residental Development**						
Client :	**City of Ottawa**	**Project Location :**	**1770 Heatherington Road, Ottawa, ON**						
Date Sampled :	**March 25, 2024**	**Borehole No:**	**BH24-15**	**Sample No.:**	**SS6**	**Depth (m) :**	**3.8-4.3**		
Sample Description :		**% Silt and Clay**	**77**	**% Sand**	**18**	**% Gravel**	**5**	**Figure :**	**27**
Sample Description :	**Silty Clay of Medium Plasticity (CI) - Some Sand, Trace Gravel**								

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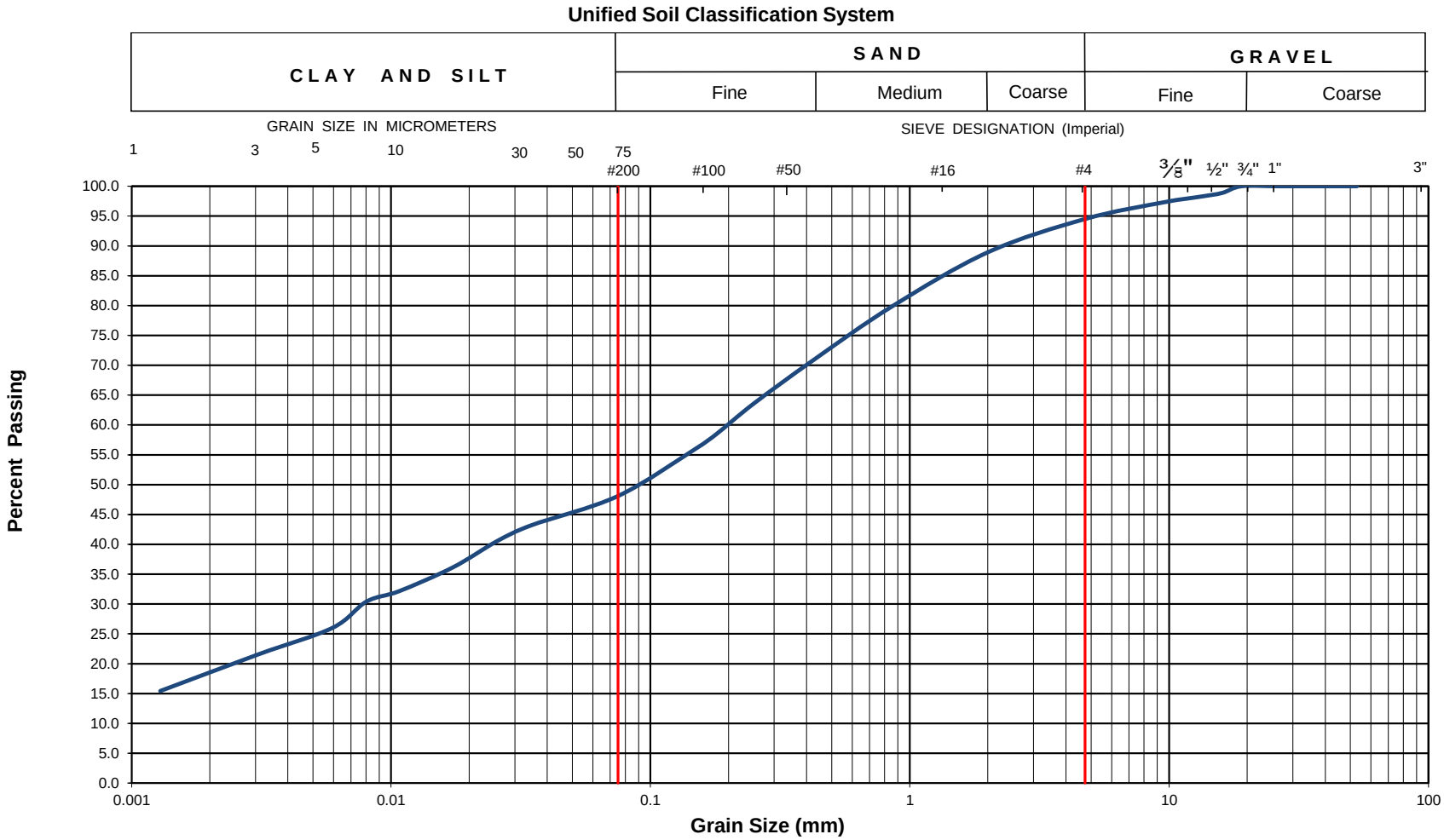
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	**OTT-22026647-A0**	**Project Name :**	**Proposed Residental Development**						
Client :	**City of Ottawa**	**Project Location :**	**1770 Heatherington Road, Ottawa, ON**						
Date Sampled :	**December 1, 2023**	**Borehole No:**	**BH23-2**		**Sample No.:**	**SS4**		**Depth (m) :**	**2.3-2.9**
Sample Description :		**% Silt and Clay**	**48**	**% Sand**	**46**	**% Gravel**	**6**	**Figure :**	**28**
Sample Description :	**GLACIAL TILL: Silty Sand (SM) - Some Clay of Low Plasticity, Trace Gravel**								

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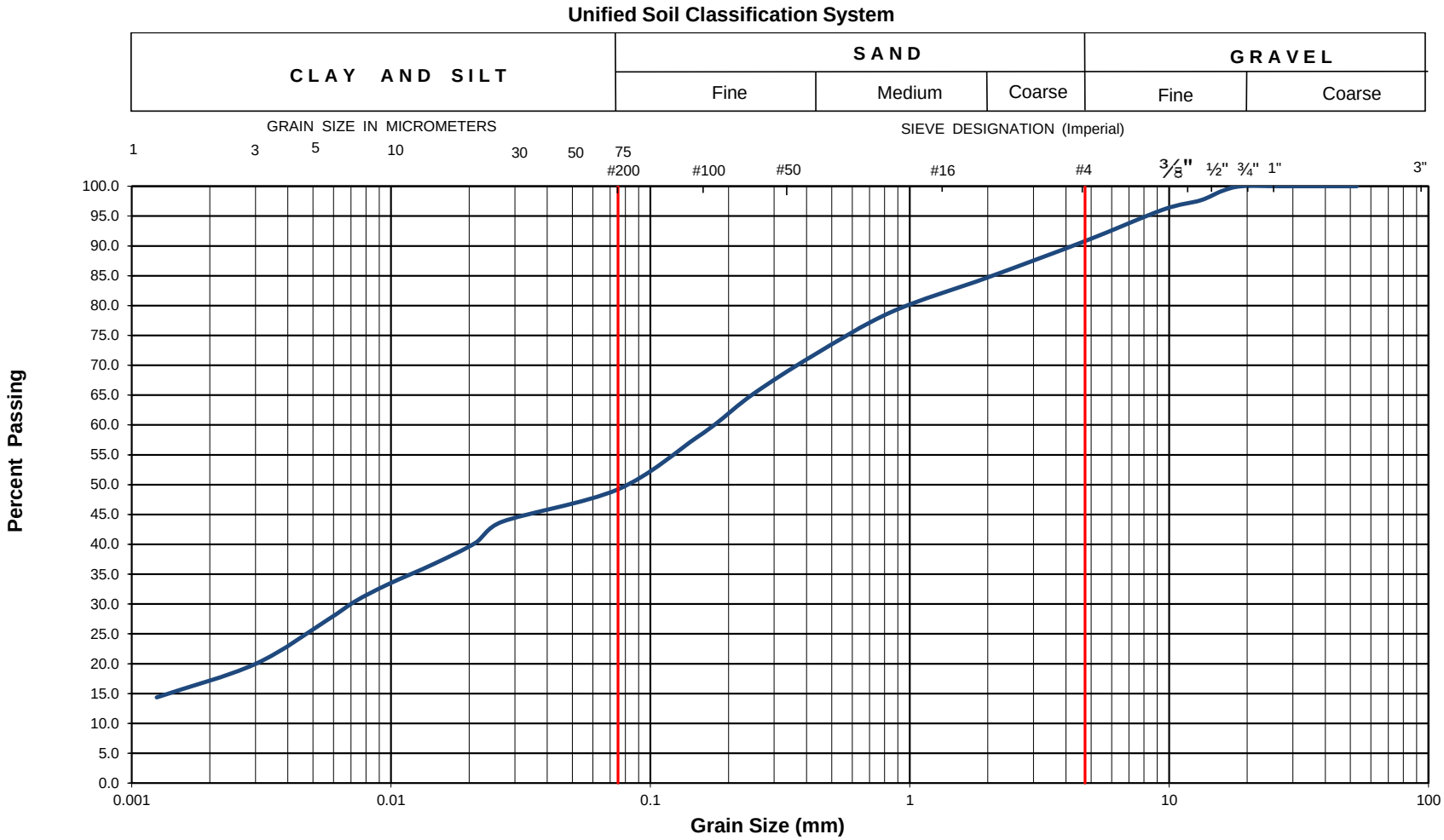
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	**OTT-22026647-A0**	**Project Name :**	**Proposed Residental Development**						
Client :	**City of Ottawa**	**Project Location :**	**1770 Heatherington Road, Ottawa, ON**						
Date Sampled :	**November 23, 2023**	**Borehole No:**	**BH23-3**	**Sample No.:**	**SS5**	**Depth (m) :**	**3.8-4.4**		
Sample Description :		**% Silt and Clay**	**49**	**% Sand**	**42**	**% Gravel**	**9**	**Figure :**	**29**
Sample Description :	**GLACIAL TILL: Silty Sand (SM) - Some Clay of Low Plasticity, Trace Gravel**								

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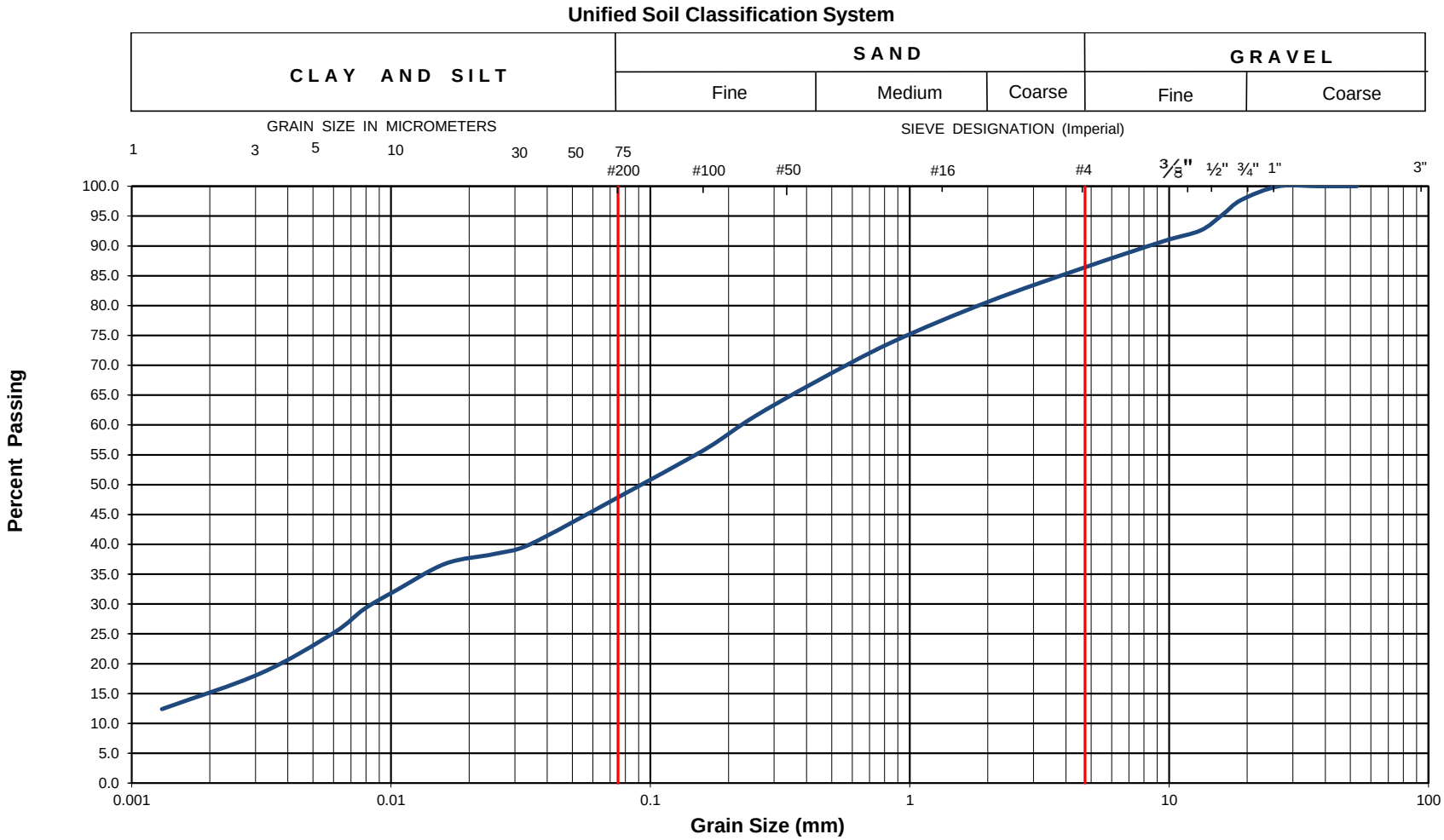
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	**OTT-22026647-A0**	**Project Name :**	**Proposed Residental Development**						
Client :	**City of Ottawa**	**Project Location :**	**1770 Heatherington Road, Ottawa, ON**						
Date Sampled :	**December 1, 2023**	**Borehole No:**	**BH23-4**	**Sample No.:**	**SS5**	**Depth (m) :**	**4.6-5.2**		
Sample Description :		**% Silt and Clay**	**48**	**% Sand**	**38**	**% Gravel**	**14**	**Figure :**	**30**
Sample Description :	**GLACIAL TILL: Silty Sand (SM) - Some Gravel and Clay of Low Plasticity**								

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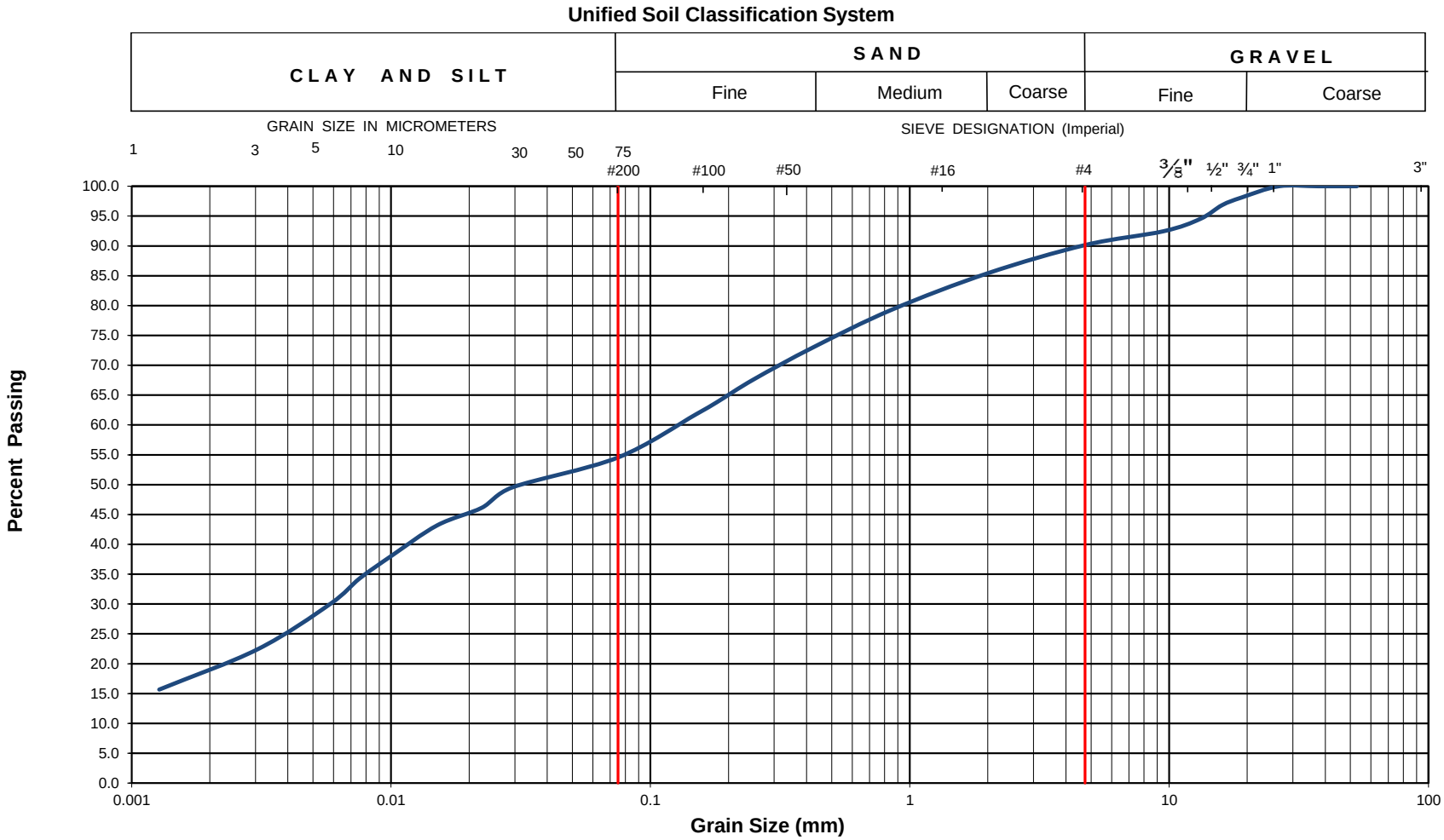
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	**OTT-22026647-A0**	**Project Name :**	**Proposed Residental Development**						
Client :	**City of Ottawa**	**Project Location :**	**1770 Heatherington Road, Ottawa, ON**						
Date Sampled :	**December 1, 2023**	**Borehole No:**	**BH23-7**		**Sample No.:**	**SS5**		**Depth (m) :**	**4.6-5.2**
Sample Description :		**% Silt and Clay**	**55**	**% Sand**	**35**	**% Gravel**	**10**	**Figure :**	**31**
Sample Description :	**GLACIAL TILL: Silty Clay of Low Plasticity (CL) - Sandy, Trace Gravel**								

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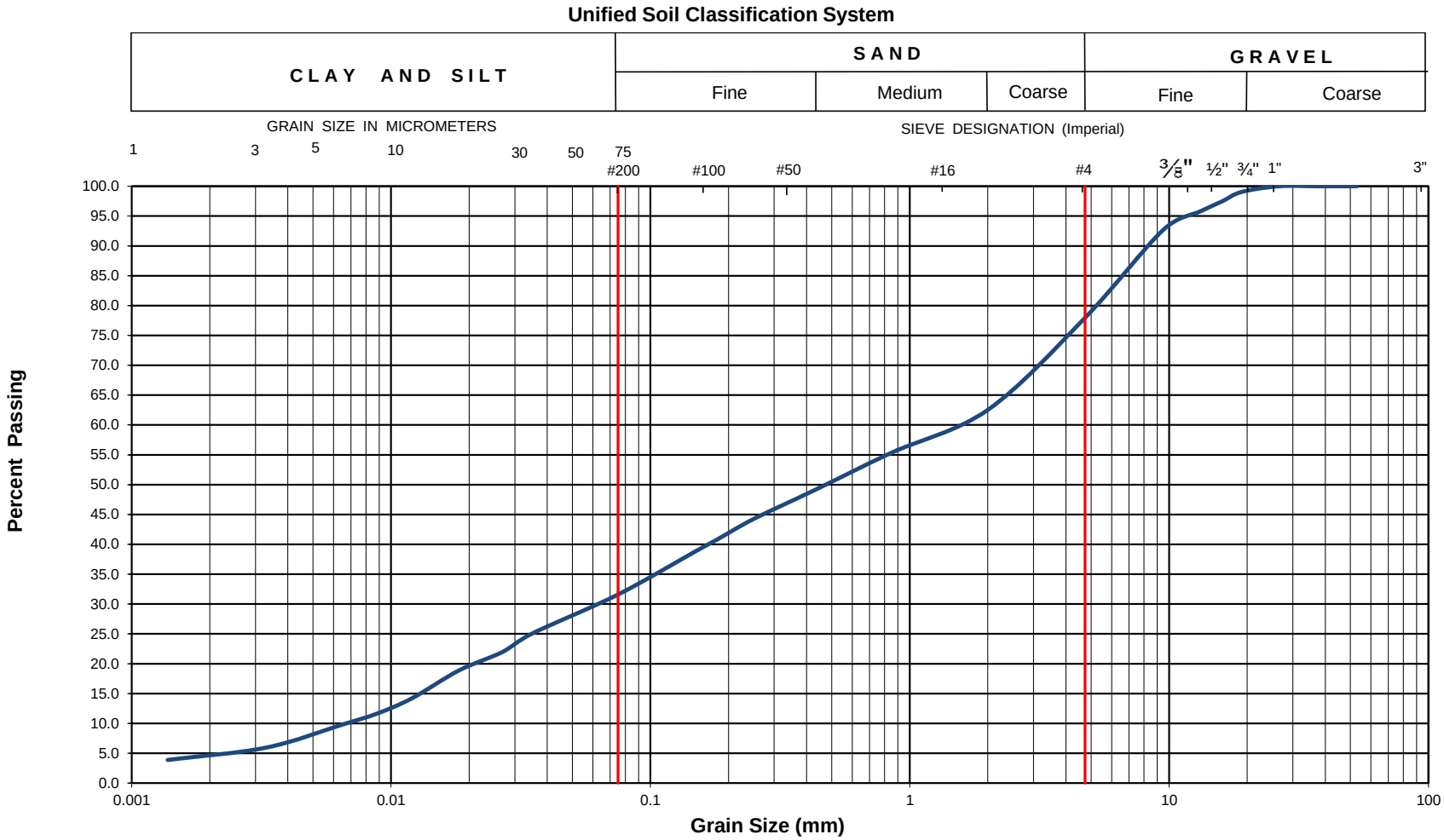
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	**OTT-22026647-A0**	**Project Name :**	**Proposed Residental Development**						
Client :	**City of Ottawa**	**Project Location :**	**1770 Heatherington Road, Ottawa, ON**						
Date Sampled :	**November 21, 2023**	**Borehole No:**	**BH23-9**		**Sample No.:**	**SS5**		**Depth (m) :**	**4.6-5.2**
Sample Description :		**% Silt and Clay**	**32**	**% Sand**	**46**	**% Gravel**	**22**	**Figure :**	**32**
Sample Description :		**GLACIAL TILL: Silty Sand (SM) - Gravelly, Trace Clay**							

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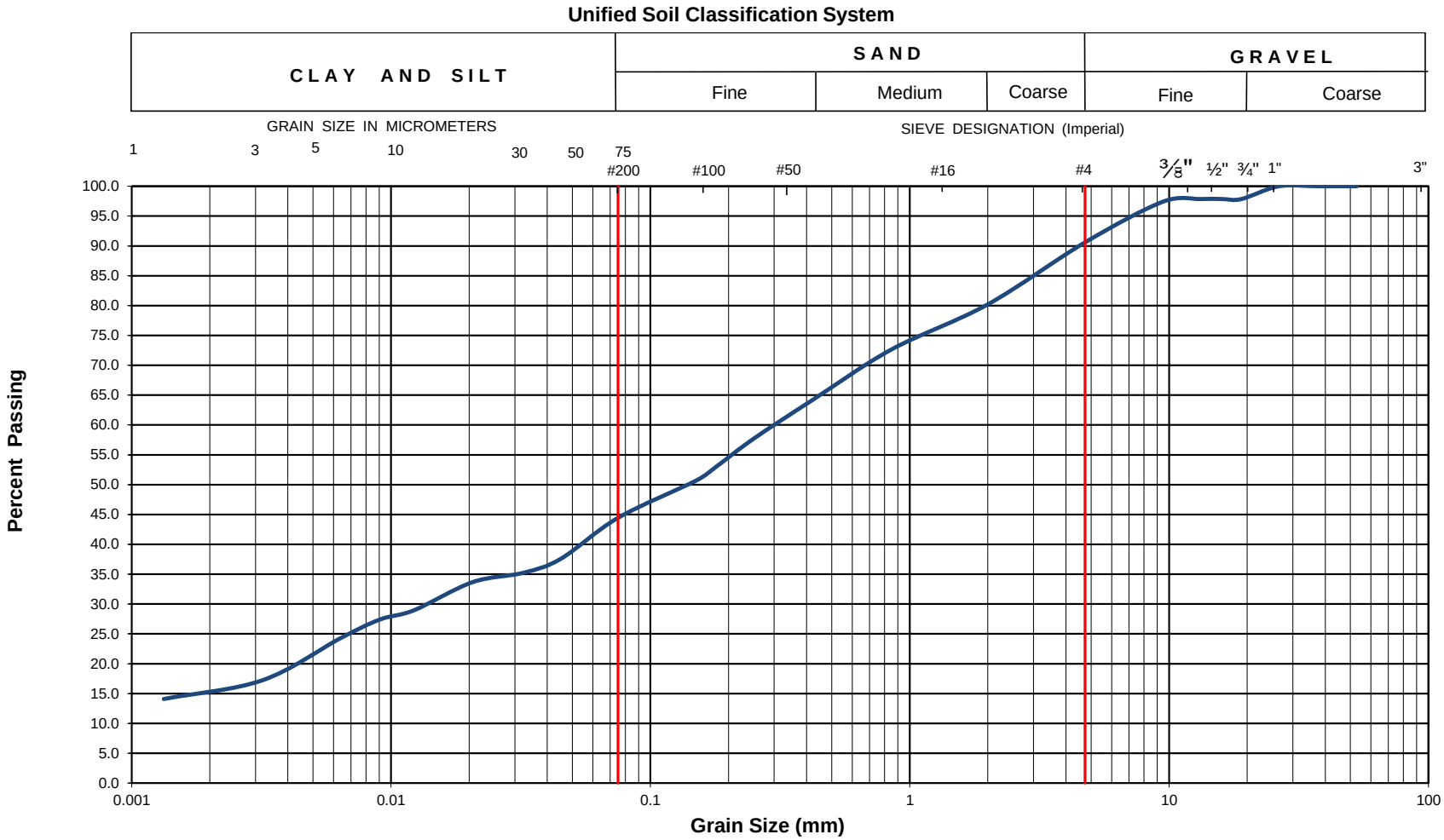
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	**OTT-22026647-A0**	**Project Name :**	**Proposed Residental Development**						
Client :	**City of Ottawa**	**Project Location :**	**1770 Heatherington Road, Ottawa, ON**						
Date Sampled :	**March 25, 2024**	**Borehole No:**	**BH24-12**	**Sample No.:**	**SS7**	**Depth (m) :**	**4.6-5.2**		
Sample Description :		**% Silt and Clay**	**44**	**% Sand**	**47**	**% Gravel**	**9**	**Figure :**	**33**
Sample Description :	**GLACIAL TILL: Silty Sand (SM) - Some Clay of Low Plasticity, Trace Gravel**								

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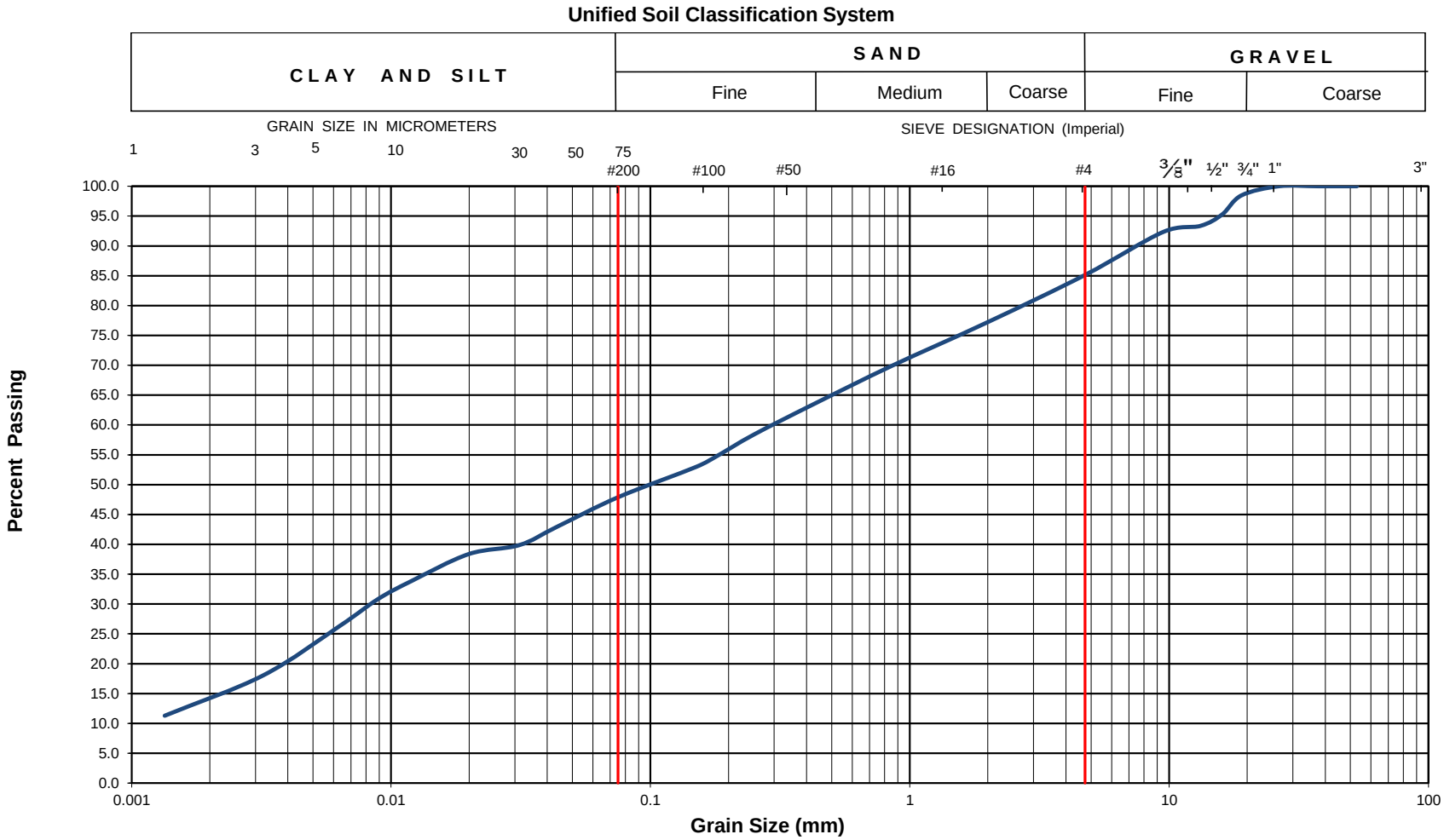
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	**OTT-22026647-A0**	**Project Name :**	**Proposed Residental Development**						
Client :	**City of Ottawa**	**Project Location :**	**1770 Heatherington Road, Ottawa, ON**						
Date Sampled :	**March 25, 2024**	**Borehole No:**	**BH24-13**	**Sample No.:**	**SS7**	**Depth (m) :**	**4.6-5.2**		
Sample Description :		**% Silt and Clay**	**48**	**% Sand**	**37**	**% Gravel**	**15**	**Figure :**	**34**
Sample Description :	**GLACIAL TILL: Silty Sand (SM) - Some Gravel and Clay of Low Plasticity**								

Appendix A – Site Photographs

Photograph No. 1: Stockpiled Sand

Photograph No. 2: Existing Berms

Photograph No. 3: Light Posts and Concrete Barriers

Photograph No. 4: Light Posts and Wooden Fence Posts

Photograph No. 5: Existing Tree with Concrete Posts

Photograph No. 6: Concrete Debris

Photograph No. 7: Stockpile of Wooden Pallets

Photograph No. 8: Concrete and Wood Debris

Photograph No. 9: Stockpiled Wood

END OF PHOTOGRAPHS

Appendix B – 2008 EXP Borehole Logs

Log of Borehole 08-10

Trow

Project No: OTGE00018293JB

Project: Preliminary Geotechnical Investigation

Location: 1770 Heatherington Road, Ottawa, Ontario

Figure No. 3

Feuille. 1 of 1

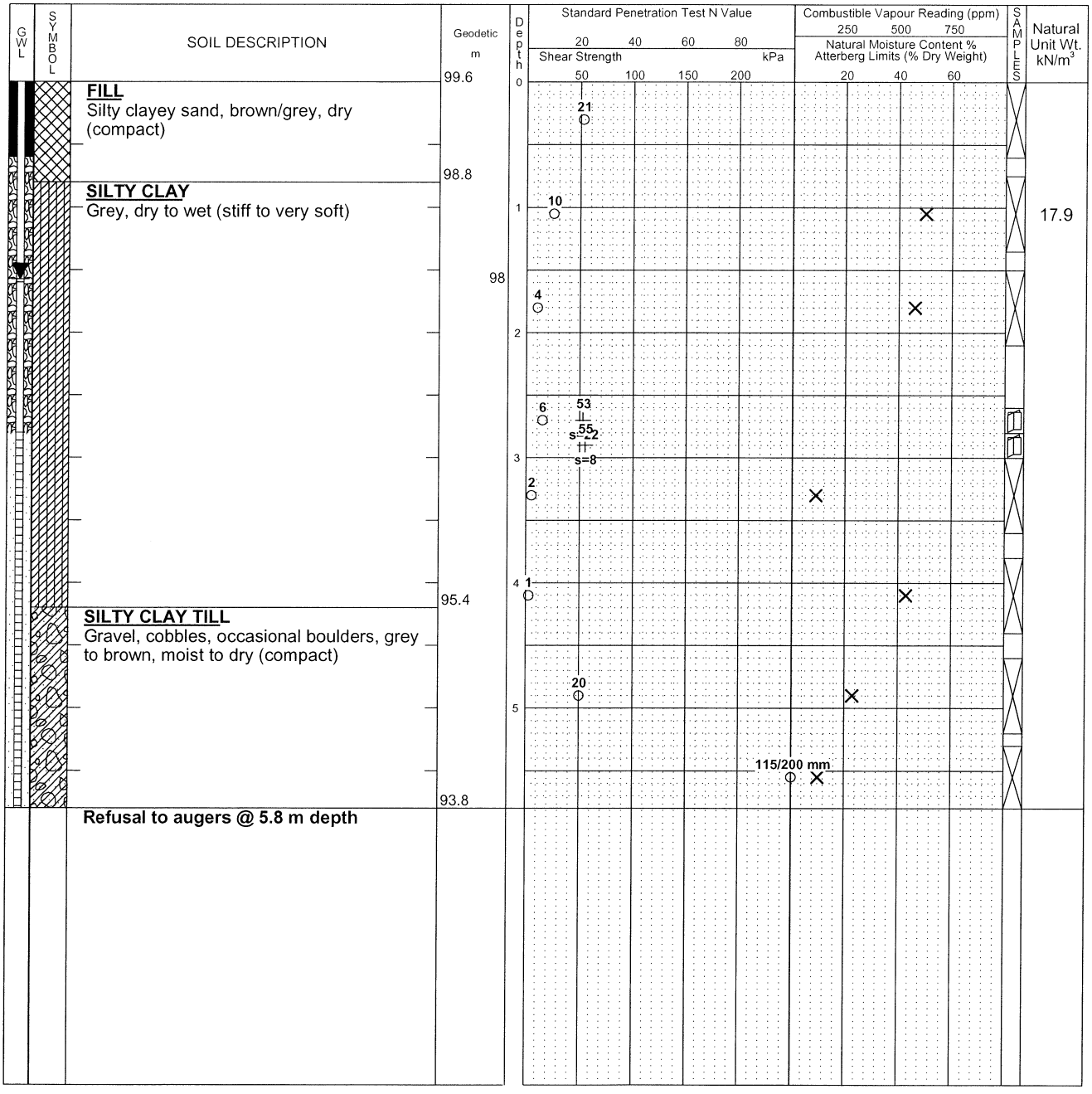
Date Drilled: August 5, 2008

Drill Type:

Datum: Geodetic

Logged by: _____ Checked by: _____

Split Spoon Sample	⊠	Combustible Vapour Reading	□
Auger Sample	▮▯	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	⊢○
Dynamic Cone Test	——	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■	Shear Strength by Penetrometer Test	▲
Shear Strength by Vane Test	+ S		



NOTES:
1. Borehole/Test Pit data requires Interpretation by Trow before use by others
2. A 19 mm slotted standpipe installed in the borehole upon completion of drilling
3. Field work supervised by a Trow representative
4. See Notes on Sample Descriptions
5. This Figure is to read with Trow Associates Inc. report OTGE00018293JB

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
6 days	1.6	-

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

LOG OF BOREHOLE BH1TO1-1.GPJ TROW OTTAWA.GDT 5/9/08

Log of Borehole 08-11

Trow

Project No: OTGE00018293JB

Project: Preliminary Geotechnical Investigation

Location: 1770 Heatherington Road, Ottawa, Ontario

Figure No. 4

Feuille. 1 of 1

Date Drilled: 'August 5, 2008

Drill Type:

Datum: Geodetic

Logged by: _____ Checked by: _____

Split Spoon Sample	⊠	Combustible Vapour Reading	□
Auger Sample	◧	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	⊢○
Dynamic Cone Test	———	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■	Shear Strength by Penetrometer Test	▲
Shear Strength by Vane Test	+ S		

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic m	Depth
		FILL Silty sand and gravel, trace clay, brown/grey, dry (very dense)	100.1	0
		SILTY CLAY Occasional gravel, brown/grey to grey, moist to wet (firm to stiff)	99.2	1
▼			98.3	2
				3
				4
		SILTY CLAY TILL Gravel, cobbles, rock fragments, occasional boulders, grey to brown, moist to dry (compact)	95.7	5
				6
		Refusal to augers @ 6.9 m depth	93.2	

Standard Penetration Test N Value: 20 40 60 80

Shear Strength kPa: 50 100 150 200

Combustible Vapour Reading (ppm): 250 500 750

Natural Moisture Content % / Atterberg Limits (% Dry Weight): 20 40 60

SAMPLES

Natural Unit Wt. kN/m³: 16.3

63 ○ ×

10 ○ ×

6 ○ ×

3 ○ ×

43 ⊢ s=c 58 ⊢ s=8

4 ○ ×

23 ○ ×

50 ○ ×

60/100 mm ⊖ ×

LOG OF BOREHOLE BH1TO1~1.GPJ TROW OTTAWA.GDT 5/9/08

NOTES:
1. Borehole/Test Pit data requires Interpretation by Trow before use by others
2. A 19 mm slotted standpipe installed in the borehole upon completion of drilling
3. Field work supervised by a Trow representative
4. See Notes on Sample Descriptions
5. This Figure is to read with Trow Associates Inc. report OTGE00018293JB

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
6 days	1.8	-

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole 08-12

Trow

Project No: OTGE00018293JB

Project: Preliminary Geotechnical Investigation

Location: 1770 Heatherington Road, Ottawa, Ontario

Figure No. 5

Feuille. 1 of 1

Date Drilled: 'August 5, 2008

Drill Type:

Datum: Geodetic

Logged by: _____ Checked by: _____

Split Spoon Sample	⊠	Combustible Vapour Reading	□
Auger Sample	◧	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	⊢○
Dynamic Cone Test	—	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■	Shear Strength by Penetrometer Test	▲
Shear Strength by Vane Test	+ S		

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic m	Depth
		FILL Sand and gravel, some silt, brown/grey, wet (compact)	100.8	0
		SILTY CLAY Brown/grey, dry (stiff)	100.0	1
▼		**SILTY SAND TO SAND TILL** Gravel, cobbles, occasional boulders, dark brown to dark grey, wet to dry (loose to very dense)	99.2	2
			98.5	3
				4
				5
				6
		Refusal to augers @ 6.4 m depth	94.4	

Standard Penetration Test N Value: 20 40 60 80

Shear Strength kPa: 50 100 150 200

Combustible Vapour Reading (ppm): 250 500 750

Natural Moisture Content % Atterberg Limits (% Dry Weight): 20 40 60

SAMPLES

Natural Unit Wt. kN/m³: 17.6

14 10 8 19 13 14 10 35 28/150 mm

LOG OF BOREHOLE BH1TO1~1.GPJ TROW OTTAWA.GDT 5/9/08

NOTES:
1. Borehole/Test Pit data requires Interpretation by Trow before use by others
2. A 19 mm slotted standpipe installed in the borehole upon completion of drilling
3. Field work supervised by a Trow representative
4. See Notes on Sample Descriptions
5. This Figure is to read with Trow Associates Inc. report OTGE00018293JB

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
6 days	2.3	-

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole MW08-13

Trow

Project No: OTGE00018293JB

Project: Preliminary Geotechnical Investigation

Location: 1770 Heatherington Road, Ottawa, Ontario

Figure No. 6

Feuille. 1 of 1

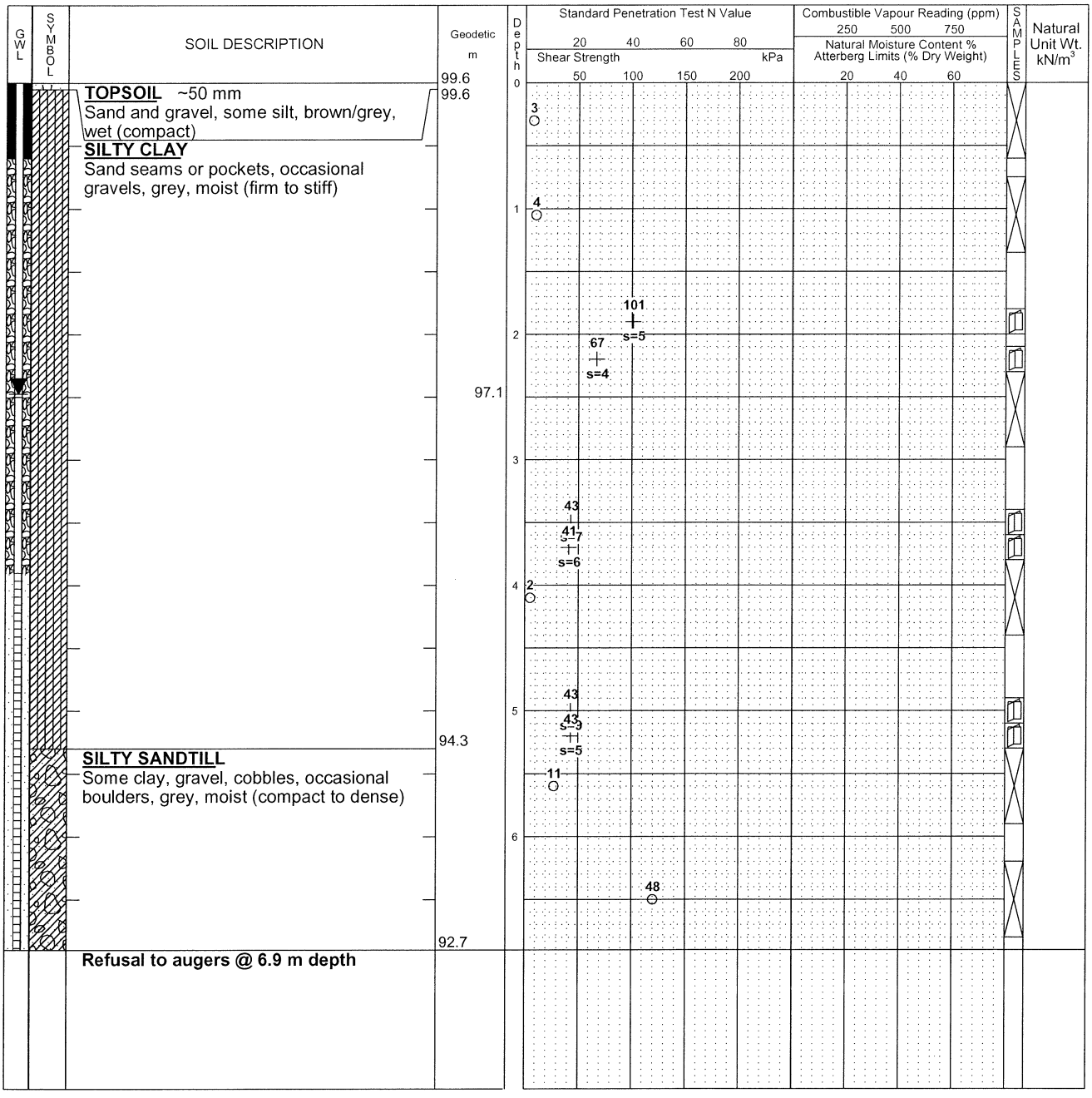
Date Drilled: 'August 5, 2008

Drill Type:

Datum: Geodetic

Logged by: _____ Checked by: _____

Split Spoon Sample	⊠	Combustible Vapour Reading	□
Auger Sample	◧	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	⊢○
Dynamic Cone Test	—	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■	Shear Strength by Penetrometer Test	▲
Shear Strength by Vane Test	+ S		



LOG OF BOREHOLE BH1TO1~1.GPJ TROW OTTAWA.GDT 5/9/08

NOTES:
1. Borehole/Test Pit data requires Interpretation by Trow before use by others
2. A 19 mm slotted standpipe installed in the borehole upon completion of drilling
3. Field work supervised by a Trow representative
4. See Notes on Sample Descriptions
5. This Figure is to read with Trow Associates Inc. report OTGE00018293JB

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
6 days	2.5	-

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole MW08-14

Trow

Project No: OTGE00018293JB

Project: Preliminary Geotechnical Investigation

Location: 1770 Heatherington Road, Ottawa, Ontario

Figure No. 7

Feuille. 1 of 1

Date Drilled: 'August 6, 2008

Drill Type:

Datum: Geodetic

Logged by: _____ Checked by: _____

Split Spoon Sample	⊠	Combustible Vapour Reading	□
Auger Sample	◧	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	⊢—○
Dynamic Cone Test	——	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■	Shear Strength by Penetrometer Test	▲
Shear Strength by Vane Test	+ S		

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic m	Depth
		TOPSOIL ~ 100 mm	100.4	0
		FILL Sand and gravel to clayey silt with sand pockets or seams, brown, moist (compact)	100.3	
				1
			99.0	
▽		**SILTY CLAY** Occasional sand pockets, grey/brown, moist (stiff to firm)		
			98.3	2
				3
		SILTY CLAYEY SAND TILL Gravel, cobbles, occasional boulders, dark grey/grey, wet (loose to compact)	97.4	
				4
			95.1	5
		WEATHERED BEDROCK Grey, wet		
			94.5	
		Refusal to augers @ 5.9 m depth		

Standard Penetration Test N Value: 20 40 60 80

Shear Strength kPa: 50 100 150 200

Combustible Vapour Reading (ppm): 250 500 750

Natural Moisture Content % Atterberg Limits (% Dry Weight): 20 40 60

SAMPLES

Natural Unit Wt. kN/m³

11 11 11 5 10 6 22 77/250 mm

NOTES:
1. Borehole/Test Pit data requires Interpretation by Trow before use by others
2. Monitoring well installed in the borehole upon completion of drilling
3. Field work supervised by a Trow representative
4. See Notes on Sample Descriptions
5. This Figure is to read with Trow Associates Inc. report OTGE00018293JB

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
5 days	2.1	-

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

LOG OF BOREHOLE BH1TO1~1.GPJ TROW OTTAWA.GDT 5/9/08

Log of Borehole MW08-15

Trow

Project No: OTGE00018293JB

Project: Preliminary Geotechnical Investigation

Location: 1770 Heatherington Road, Ottawa, Ontario

Figure No. 8

Feuille. 1 of 1

Date Drilled: 'August 6, 2008

Drill Type:

Datum: Geodetic

Logged by: _____ Checked by: _____

Split Spoon Sample	⊠	Combustible Vapour Reading	□
Auger Sample	◧	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	⊢○
Dynamic Cone Test	—	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■	Shear Strength by Penetrometer Test	▲
Shear Strength by Vane Test	+ S		

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic m	Depth	Standard Penetration Test N Value / Shear Strength kPa	Combustible Vapour Reading (ppm) / Natural Moisture Content % / Atterberg Limits (% Dry Weight)	SAMPLES	Natural Unit Wt. kN/m³
		ASPHALT ~ 100 mm	100.4	0	20 40 60 80; 50 100 150 200	250 500 750; 20 40 60		
		GRANULAR FILL Gravel, some some sand, brown, moist (compact)	100.3					
		FILL Silty sand with trace clay silty clay with sand pockets or seams and trace gravel, grey, moist (loose)	99.9		10			
				1	5			
▼			98.8					
				2	2	×		
		SILTY CLAY Grey, moist (soft)	98.0		2	×		16.4
				3	2			
		SILTY CLAY TO SILTY CLAYEY SAND TILL Gravel, cobbles, occasional boulders, grey, moist to wet (very loose to compact)	96.9	4	4	×		
				5	15			
					30	×		
				6				
		Refusal to augers @ 6.3 m depth	94.1					

LOG OF BOREHOLE BH1TO1-1.GPJ TROW.OTTAWA.GDT 5/9/08

NOTES:
1. Borehole/Test Pit data requires Interpretation by Trow before use by others
2. Monitoring well installed in the borehole upon completion of drilling
3. Field work supervised by a Trow representative
4. See Notes on Sample Descriptions
5. This Figure is to read with Trow Associates Inc. report OTGE00018293JB

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
5 days	1.6	-

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole MW08-16

Trow

Project No: OTGE00018293JB

Project: Preliminary Geotechnical Investigation

Location: 1770 Heatherington Road, Ottawa, Ontario

Figure No. 9

Feuille. 1 of 1

Date Drilled: 'August 6, 2008

Drill Type:

Datum: Geodetic

Logged by: _____ Checked by: _____

Split Spoon Sample	⊠	Combustible Vapour Reading	□
Auger Sample	◧	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	⊢○
Dynamic Cone Test	———	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■	Shear Strength by Penetrometer Test	▲
Shear Strength by Vane Test	+ S		

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic m	Depth
		ASPHALT ~ 100 mm	100.2	0
		GRANULAR FILL	100.1	
		Sand and gravel, brown, dry (very dense)	99.8	
		SILTY CLAY		
		Grey, moist (stiff to soft)		1
▼			98.4	2
			97.2	3
		SILTY CLAY TO SILTY CLAYEY SAND TILL		
		Gravel, cobbles, occasional boulders, grey, moist to wet (very loose to compact)		4
				5
			94.3	
		Refusal to augers @ 5.9 m depth		

Standard Penetration Test N Value: 20 40 60 80 — Shear Strength 50 100 150 200 kPa

Combustible Vapour Reading (ppm): 250 500 750 — Natural Moisture Content % Atterberg Limits (% Dry Weight): 20 40 60

SAMPLES

Natural Unit Wt. kN/m³

55, 9, 5, 3, 10, 12, 12, 27

NOTES:
1. Borehole/Test Pit data requires Interpretation by Trow before use by others
2. Monitoring well installed in the borehole upon completion of drilling
3. Field work supervised by a Trow representative
4. See Notes on Sample Descriptions
5. This Figure is to read with Trow Associates Inc. report OTGE00018293JB

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
5 days	1.8	-

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

LOG OF BOREHOLE BH1TO1~1.GPJ TROW OTTAWA.GDT 5/9/08

Log of Borehole MW08-17

Trow

Project No: OTGE00018293JB

Project: Preliminary Geotechnical Investigation

Location: 1770 Heatherington Road, Ottawa, Ontario

Figure No. 10

Feuille. 1 of 1

Date Drilled: 'August 6, 2008

Drill Type:

Datum: Geodetic

Logged by: _____ Checked by: _____

Split Spoon Sample	⊠	Combustible Vapour Reading	□
Auger Sample	◨	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	⊢○
Dynamic Cone Test	——	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■	Shear Strength by Penetrometer Test	▲
Shear Strength by Vane Test	+ S		

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic m	Depth
		TOPSOIL ~ 100 mm	100.4	0
		100.3		
		FILL		
		Sand and gravel to silty sand and some gravel, brown, moist		1
			98.8	
				2
			97.9	
		SILTY CLAY TILL		
		Gravel, cobbles, occasional boulders, grey, moist to wet		3
				4
				5
			94.5	
		Refusal to augers @ 5.9 m depth		

Standard Penetration Test N Value: 20 40 60 80

Shear Strength: 50 100 150 200 kPa

Combustible Vapour Reading (ppm): 250 500 750

Natural Moisture Content % Atterberg Limits (% Dry Weight): 20 40 60

SAMPLES

Natural Unit Wt. kN/m³

NOTES:
1. Borehole/Test Pit data requires Interpretation by Trow before use by others
2. Monitoring well installed in the borehole upon completion of drilling
3. Field work supervised by a Trow representative
4. See Notes on Sample Descriptions
5. This Figure is to read with Trow Associates Inc. report OTGE00018293JB

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
6 days	1.6	-

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

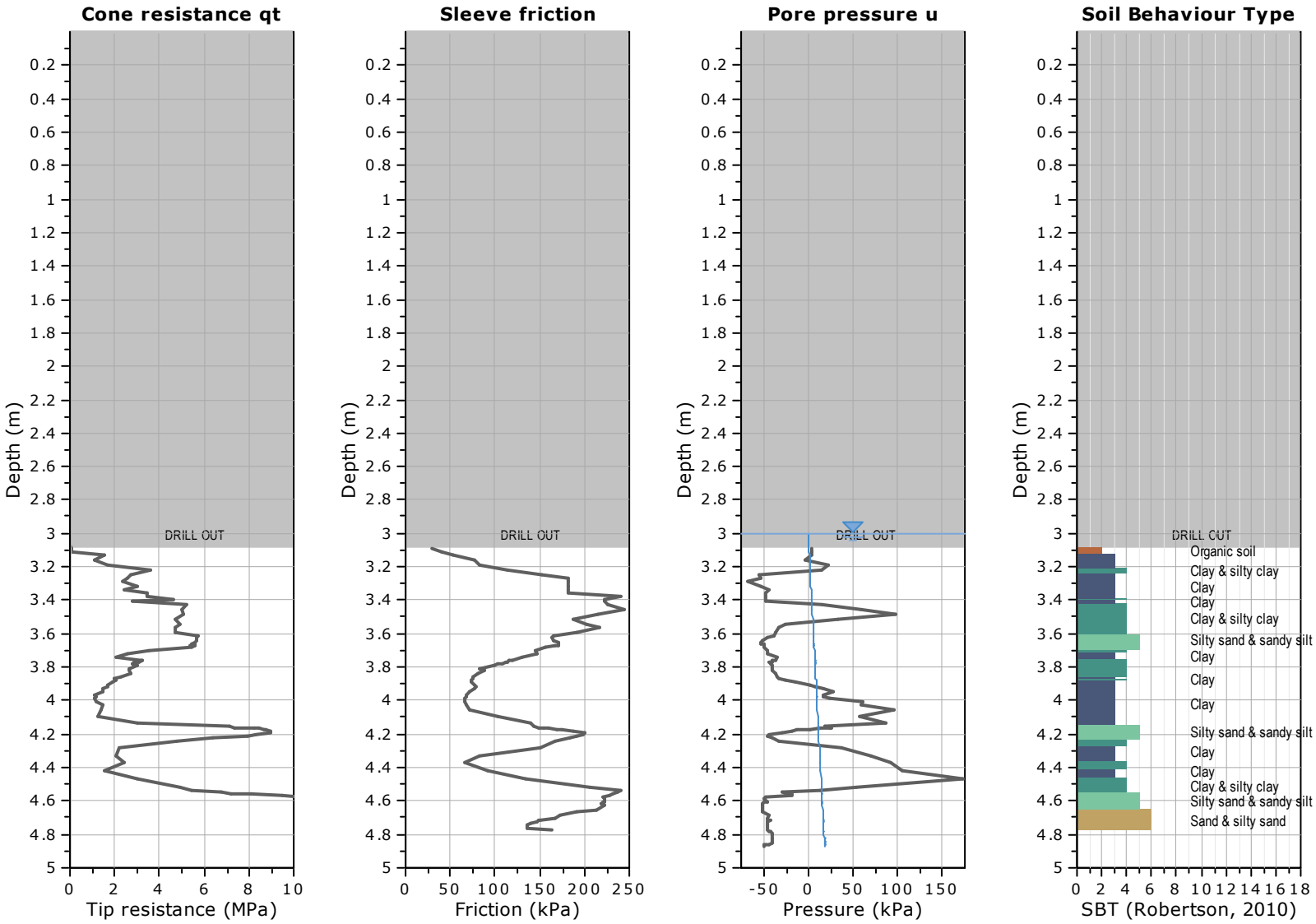
LOG OF BOREHOLE BH1TO1-1.GPJ TROW.OTTAWA.GDT 5/9/08

Appendix C – Piezocone Penetration (CPT) Results

EXP Services
2650 Queensview Drive, Suite 100
Ottawa, ON K2B 8H6
http://www.exp.com

CPT-1
Total depth: 4.87 m, Date: 2024-03-26
Cone Type: Vertek 5t
Cone Operator: K. Simoneau, ing., M.Sc.

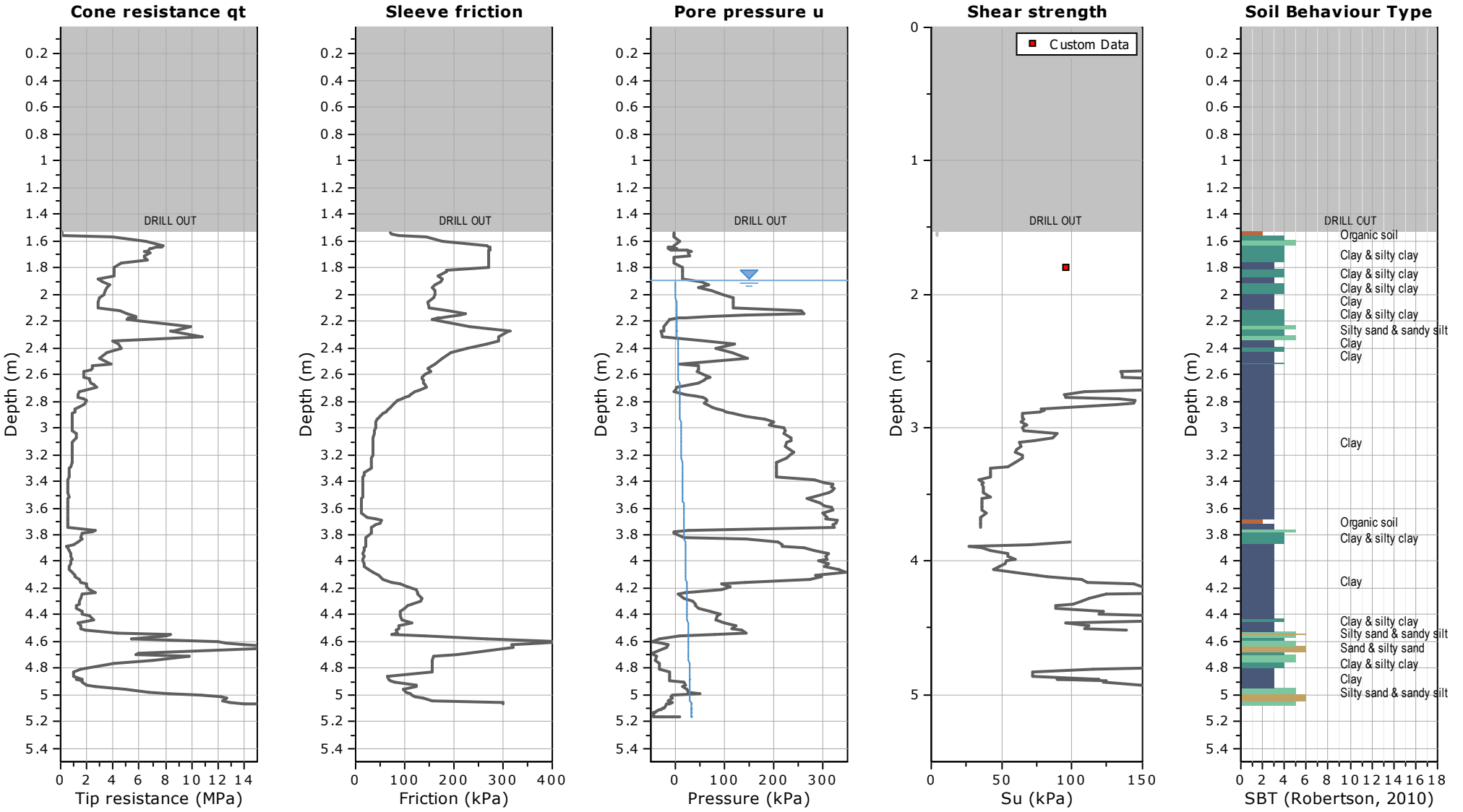
Project: Proposed Residential Development
Location: 1770 Heatherington Road, Ottawa, ON



EXP Services
2650 Queensview Drive, Suite 100
Ottawa, ON K2B 8H6
http://www.exp.com

CPT-2
Total depth: 5.17 m, Date: 2024-03-26
Cone Type: Vertek 5t
Cone Operator: K. Simoneau, ing., M.Sc.

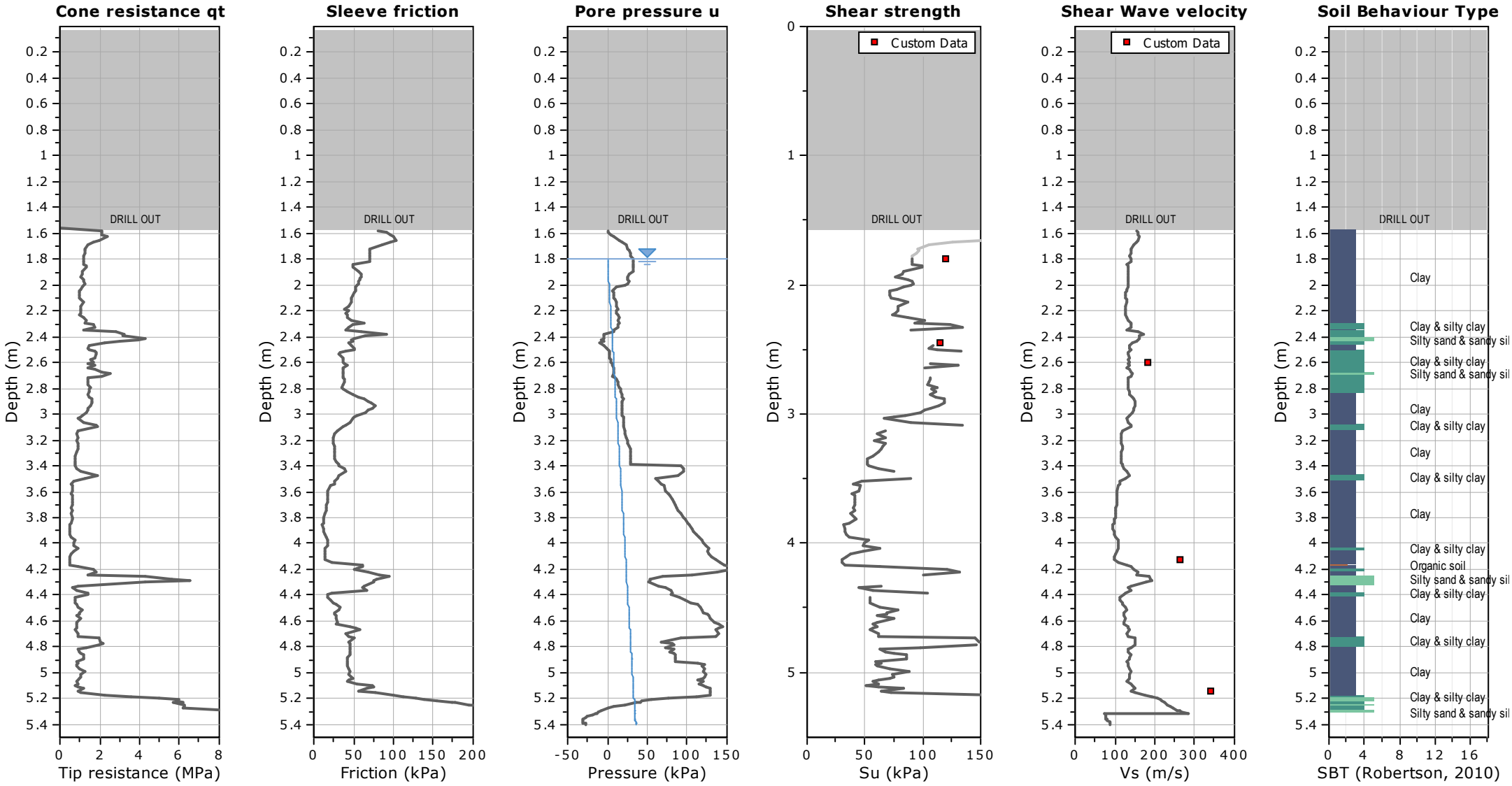
Project: Proposed Residential Development
Location: 1770 Heatherington Road, Ottawa, ON



EXP Services
2650 Queensview Drive, Suite 100
Ottawa, ON K2B 8H6
http://www.exp.com

SCPT-3
Total depth: 5.40 m, Date: 2024-03-26
Cone Type: Vertek 5t
Cone Operator: K. Simoneau, ing., M.Sc.

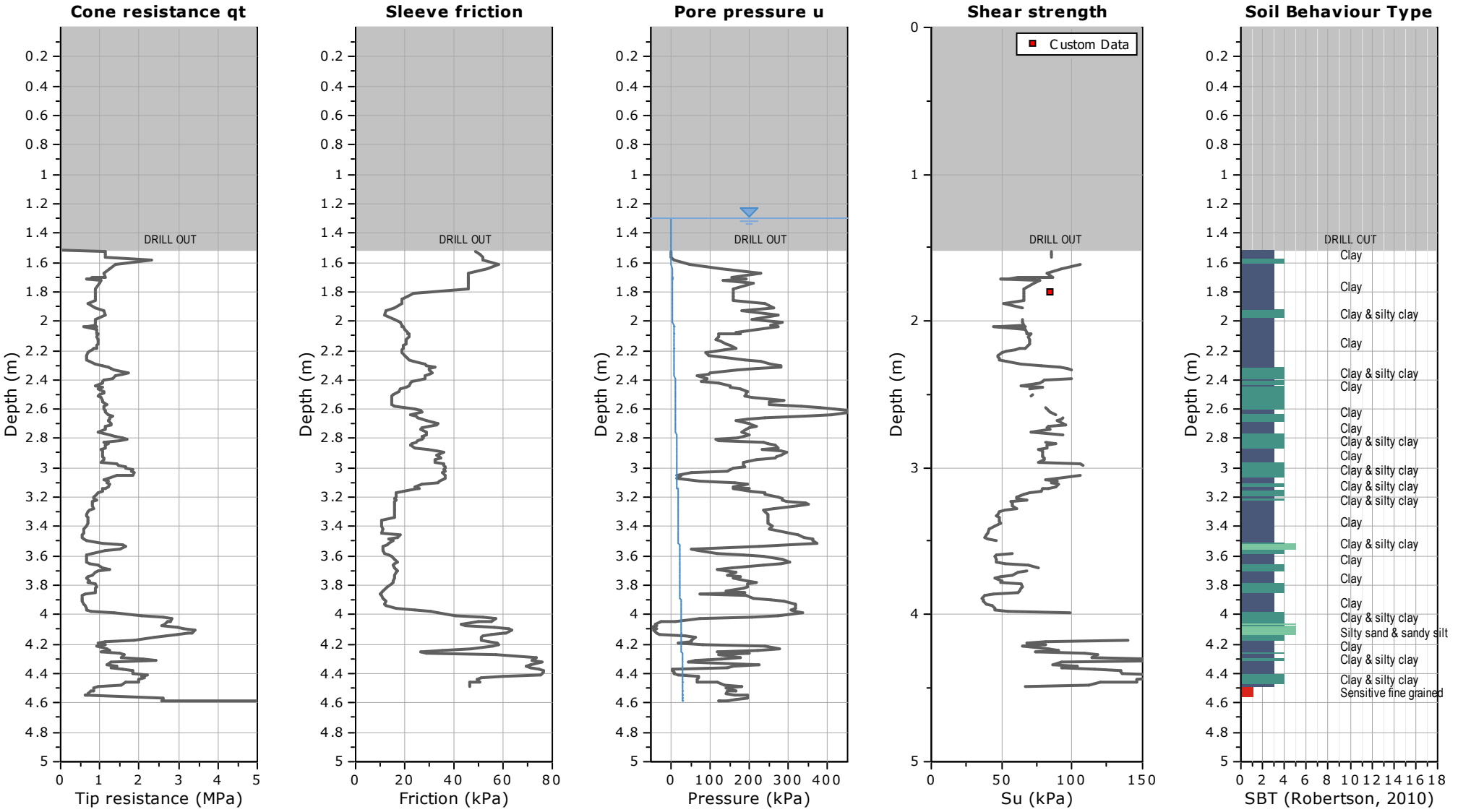
Project: Proposed Residential Development
Location: 1770 Heatherington Road, Ottawa, ON



EXP Services
2650 Queensview Drive, Suite 100
Ottawa, ON K2B 8H6
http://www.exp.com

CPT-4
Total depth: 4.59 m, Date: 2024-03-26
Cone Type: Vertek 5t
Cone Operator: K. Simoneau, ing., M.Sc.

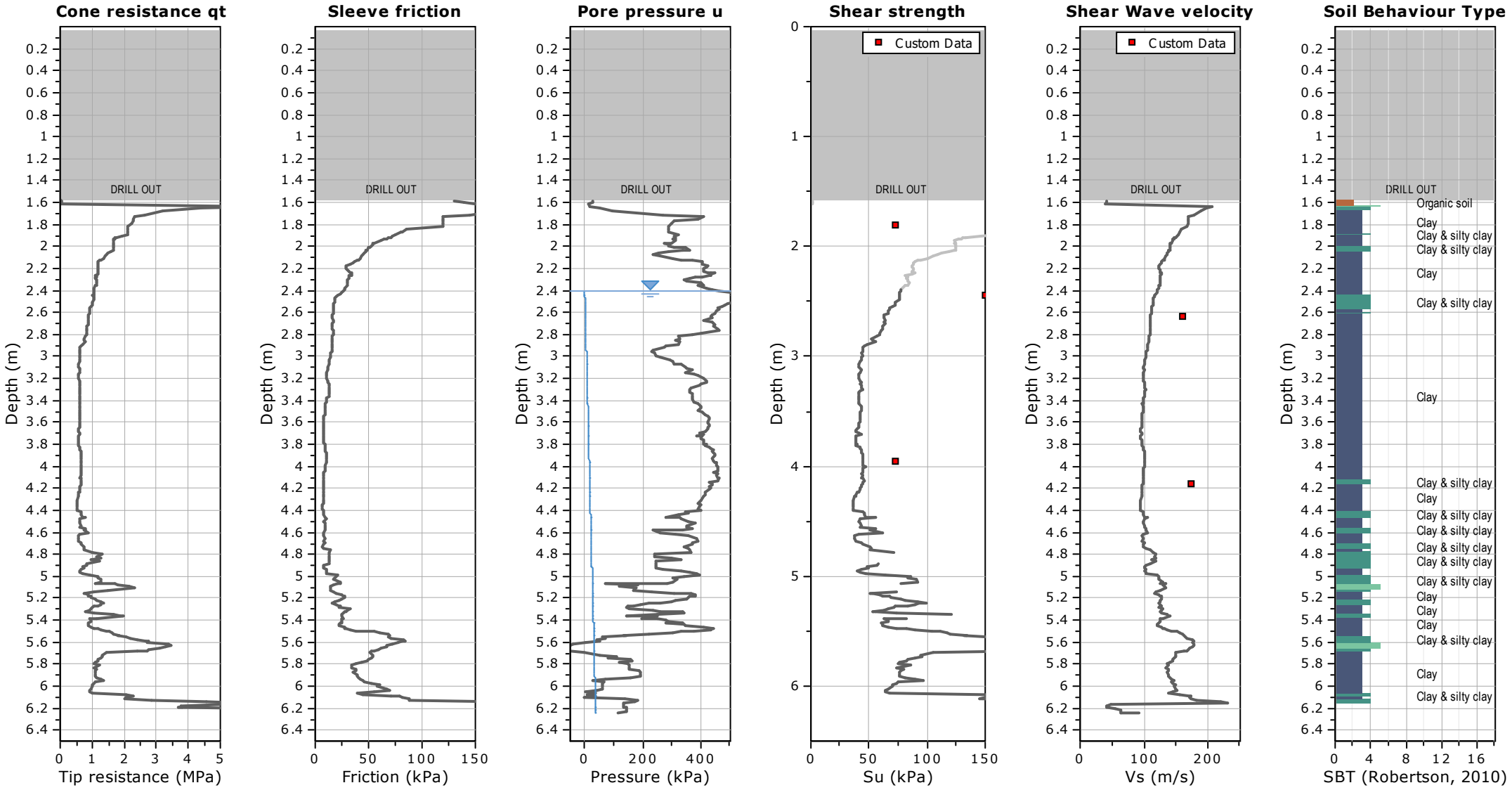
Project: Proposed Residential Development
Location: 1770 Heatherington Road, Ottawa, ON



EXP Services
2650 Queensview Drive, Suite 100
Ottawa, ON K2B 8H6
http://www.exp.com

SCPT-5
Total depth: 6.24 m, Date: 2024-03-26
Cone Type: Vertek 5t
Cone Operator: K. Simoneau, ing., M.Sc.

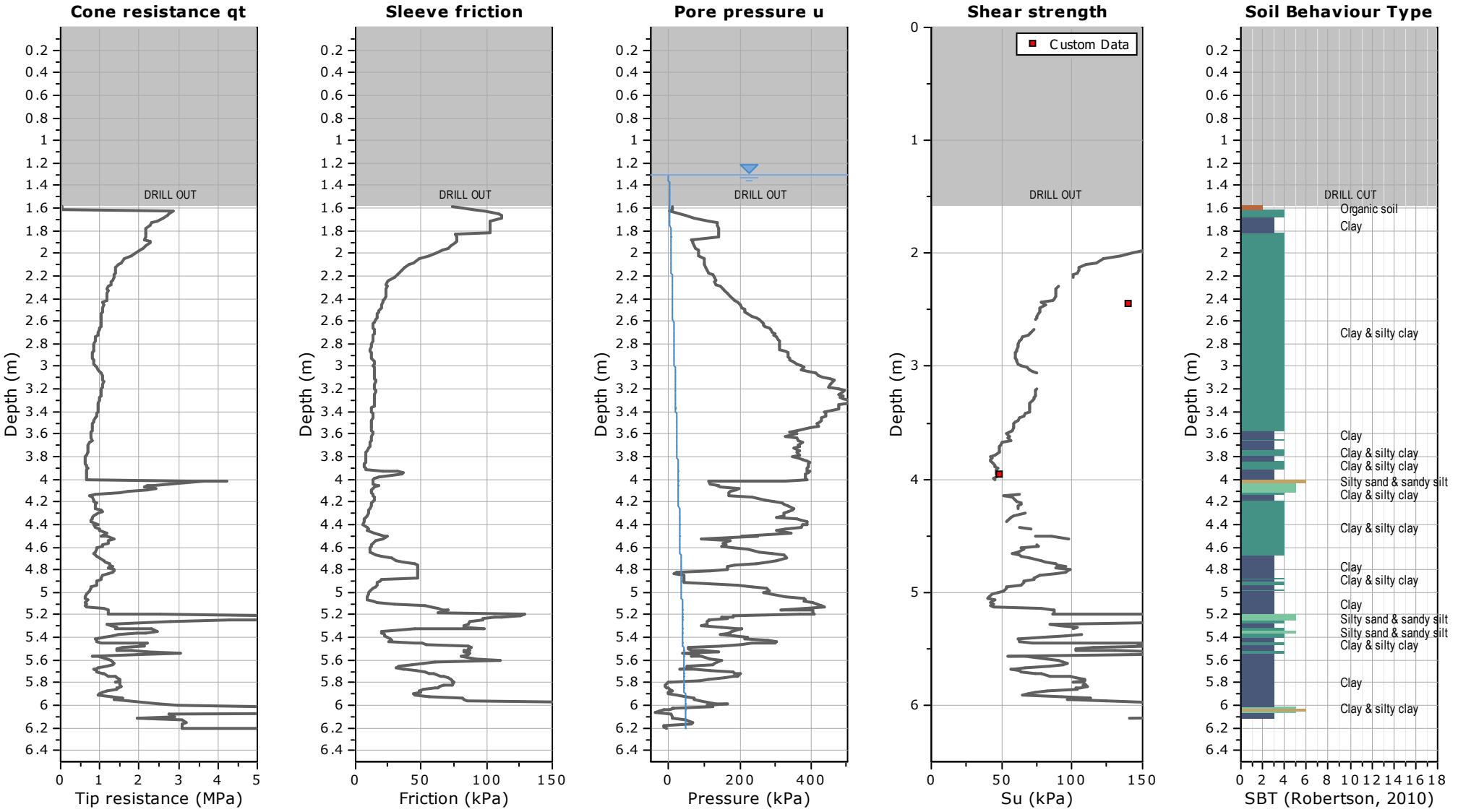
Project: Proposed Residential Development
Location: 1770 Heatherington Road, Ottawa, ON



EXP Services
2650 Queensview Drive, Suite 100
Ottawa, ON K2B 8H6
http://www.exp.com

CPT-6
Total depth: 6.21 m, Date: 2024-03-26
Cone Type: Vertek 5t
Cone Operator: K. Simoneau, ing., M.Sc.

Project: Proposed Residential Development
Location: 1770 Heatherington Road, Ottawa, ON



Appendix D – Consolidation Test Results

Stantec Consulting Ltd.
400 - 1331 Clyde Avenue, Ottawa ON K2C 3G4

January 6, 2024
File: 121624678

Attention: Ismail Taki, M.Eng., P.Eng.
Exp Services Inc
2650 Queensview Drive
Suite 100
Ottawa, Ontario, Canada, K2B 8H6
Tel: 1-613-853-1350
E-mail: ismail.taki@exp.com

Dear Mr. Taki,

Reference: Consolidation Test Results: Proposed Development, 1770 Heatherington Road, Ottawa, ON., Exp Services Inc., File # 22026647-A0

This letter presents the results of one-dimensional consolidation test carried out on one shelby tube sample in accordance with ASTM D2435/D2435M – 11(2020). The tests result is provided in the attached tables and figures.

Summary of sample tested

Sample ID	Depth (ft)	Date sampled
BH1 ST1	10-12	N/A

This letter provides test results only and does not constitute any interpretation or engineering recommendations with respect to material suitability or specification compliance.

We trust the information presented herein meets your present requirements. Should you have any questions or require additional information, please do not hesitate to contact us.

Regards,

Stantec Consulting Ltd.

Ramin Ghassemi Ph.D., P.Eng.
Geotechnical Engineer
Direct: 613 722-4420
Mobile: 437 775-7625
Ramin.ghassemi@stantec.com

v:\01216\active\laboratory_standing_offers\2023-laboratory standing offers\121624678 exp services inc\one consolidation, exp file#22026647-a0\121624678_let_consolidation_bh1 st1.docx

CONSOLIDATION TEST SUMMARY

SAMPLE IDENTIFICATION

Borehole No. :	BH1	Sample No. :	ST1
		Sample Depth (ft) :	10-12

TEST CONDITIONS

Test Type :	ASTM D2435/D2435M	Date Started :	20-Dec-23
Load Duration (hr) :	24	Date Completed :	4-Jan-24

SAMPLE DIMENSIONS AND PROPERTIES _ INITIAL

Sample Height (mm) :	20.00	Unit Weight (kN/m^3) :	16.29
Sample Diameter (mm) :	50.00	Dry Unit Weight (kN/m^3) :	10.28
Area (cm^2) :	19.63	Specific Gravity : (Assumed)	2.750
Volume (cm^3) :	39.27	Solid Height (mm) :	7.62
Water Content (%) :	58.49	Volume of Solids (cm^3) :	14.97
Wet Mass (g) :	65.25	Volume of Voids (cm^3) :	24.30
Dry Mass (g) :	41.17	Degree of Saturation (%) :	99.10

TEST COMPUTATIONS

Axial Stress (kPa)	Height (H) (mm)	Corrected Deformation (ΔH) (mm)	Axial Strain (ε_a) (%)	Void Ratio e	t_{90} (min)	C_v (cm^2/s)	m_v (m^2/kN)	k (cm/s)
0	20.0000	0.0000	0.00	1.623				
5	19.8655	0.1345	0.67	1.605	0.89	1.59E+00	1.34E-03	2.09E-08
10	19.7593	0.2407	1.20	1.592	4.21	3.30E-01	1.06E-03	3.44E-09
20	19.6324	0.3676	1.84	1.575	4.10	3.35E-01	6.34E-04	2.09E-09
40	19.4230	0.5770	2.89	1.547	3.86	3.50E-01	5.23E-04	1.80E-09
80	19.0541	0.9459	4.73	1.499	4.23	3.10E-01	4.61E-04	1.40E-09
160	18.1998	1.8002	9.00	1.387	6.24	1.99E-01	5.34E-04	1.04E-09
320	16.6613	3.3387	16.69	1.185	13.56	8.13E-02	4.81E-04	3.84E-10
480	15.6679	4.3321	21.66	1.055	29.94	3.15E-02	3.10E-04	9.58E-11
160	15.7070	4.2930	21.47	1.060				
40	15.9734	4.0266	20.13	1.095				
160	15.8170	4.1830	20.92	1.074	2.55	3.50E-01	6.52E-05	2.24E-10
480	15.4090	4.5910	22.96	1.021	2.51	3.44E-01	6.38E-05	2.15E-10
720	14.7047	5.2953	26.48	0.929	18.08	4.50E-02	1.47E-04	6.48E-11
960	14.1585	5.8415	29.21	0.857	14.12	5.28E-02	1.14E-04	5.90E-11
1920	12.9790	7.0210	35.11	0.702	5.00	1.33E-01	6.14E-05	8.01E-11

SAMPLE DIMENSIONS AND PROPERTIES _ FINAL

Sample Height (mm) :	12.98	Unit Weight (kN/m^3) :	20.63
Sample Diameter (mm) :	50.00	Dry Unit Weight (kN/m^3) :	15.84
Area (cm^2) :	19.63	Specific Gravity (Assumed) :	2.750
Volume (cm^3) :	25.48	Solid Height (mm) :	7.62
Water Content (%) :	30.22	Volume of Solids (cm^3) :	14.97
Wet Mass (g) :	53.61	Volume of Voids (cm^3) :	10.51
Dry Mass (g) :	41.17		

Project No. :	121624678	Prepared By :	DB
Date :	8-Jan-24	Checked By :	RG

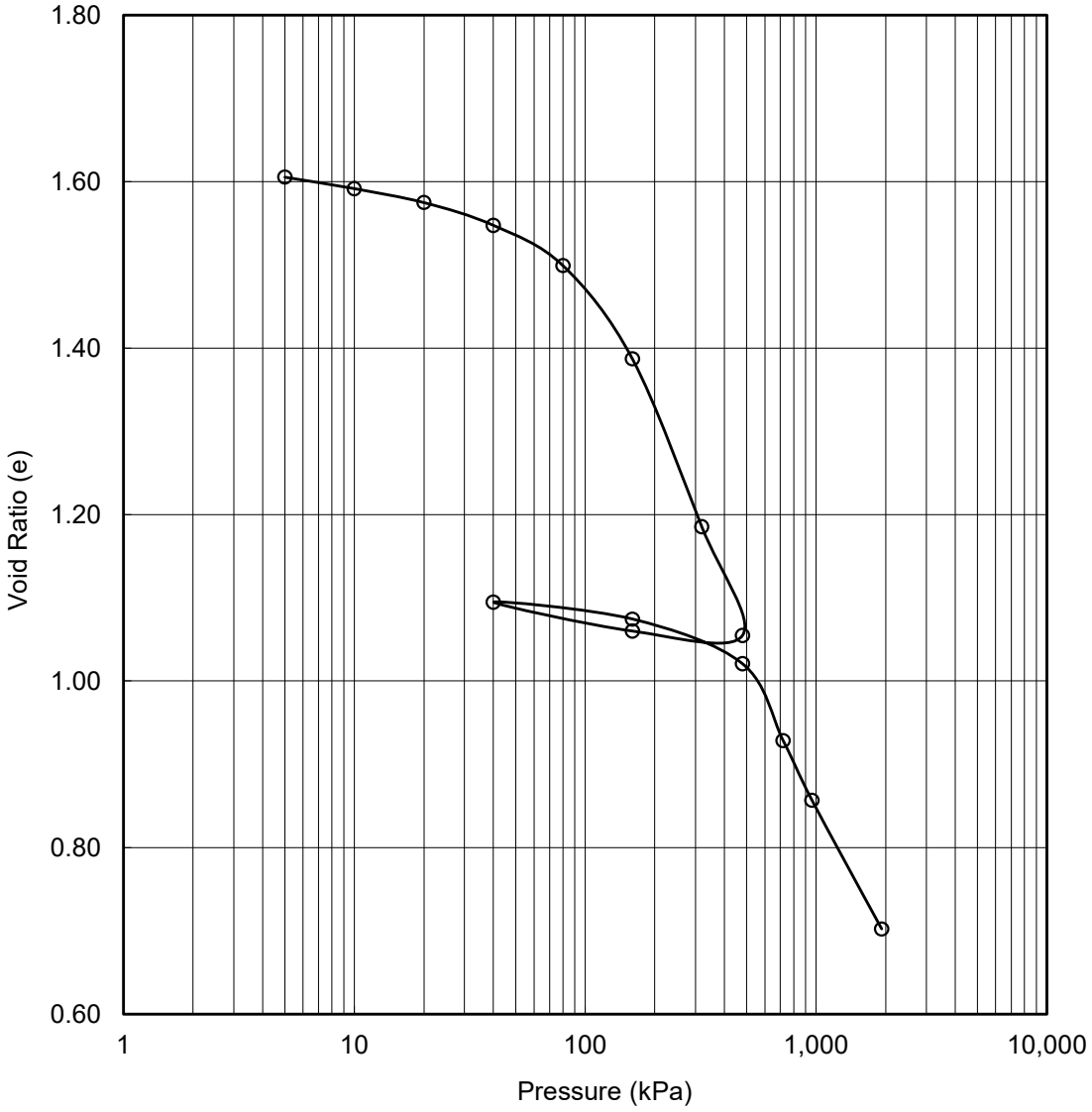
Stantec

CONSOLIDATION TEST	FIGURE 1

Proposed Development

BH1, ST1

Void Ratio vs Pressure



Soil Type :	*Silty clay, firm to stiff, grey, friable, wet*					
	e_o =	1.623	w_L =	N/A	σ_{v0}' =	kPa
	w =	58.5%	w_P =	N/A	σ_P' =	kPa
	γ =	16.29 kN/m^3	PI =	N/A		
	Gs =	2.750 Assumed				

Project No. : 121624678
Date : 8-Jan-24

Stantec

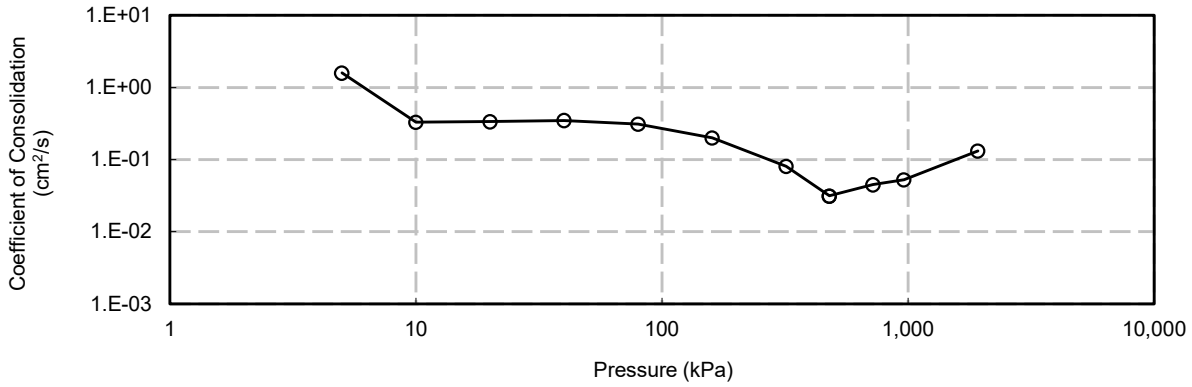
Prepared By : DB
Checked By : RG

CONSOLIDATION TEST	FIGURES 2, 3 & 4

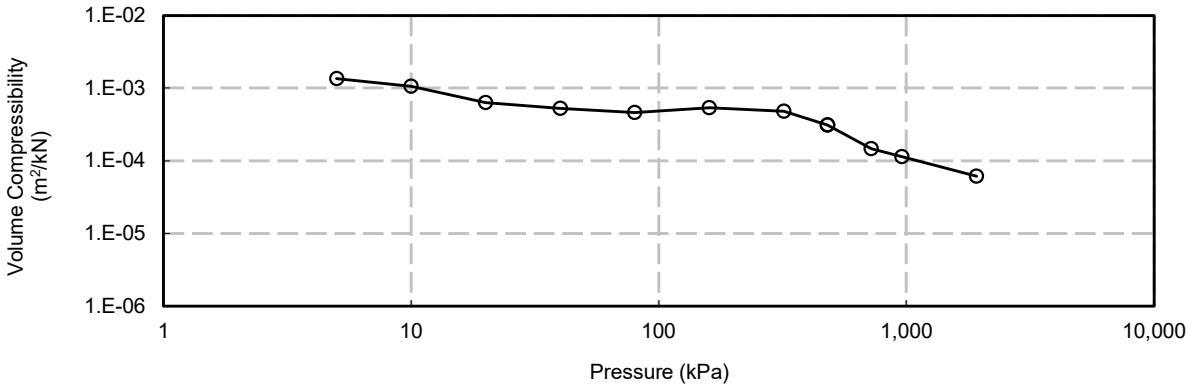
Proposed Development

BH1, ST1

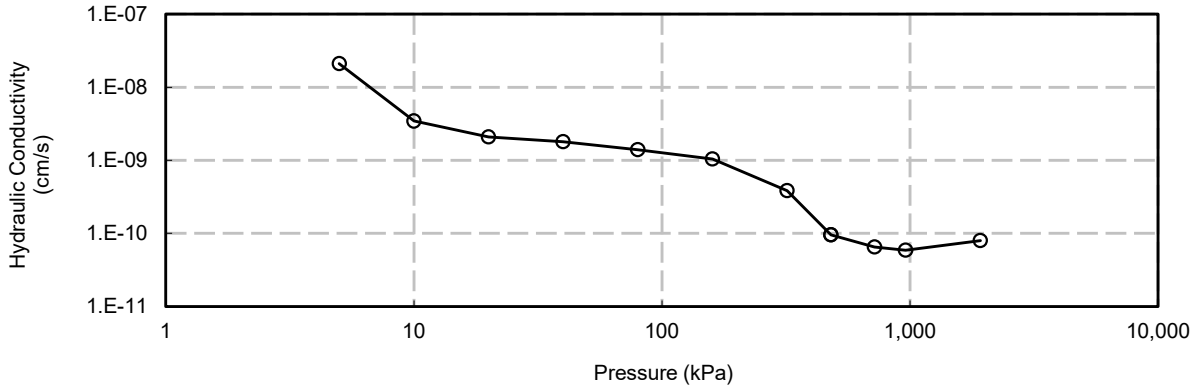
Cv vs Pressure



mv vs Pressure



k vs Pressure



Project No. :	121624678	Prepared By :	DB
Date :	8-Jan-24	Checked By :	RG

Proposed Development	**PHOTOS 1 & 2**

1770 Heatherington Road, Ottawa, ON

Silty clay, firm to stiff, grey, friable, wet

BH1 SS1-Top half of upper section is disturbed; lower half of bottom section is silty clay till

BH1 SS1-Top half of upper section is disturbed; lower half of bottom section is silty clay till

Project No. : 121624678

Date : 8-Jan-2024

Stantec

Prepared by : DB

Checked by : RG

Appendix E – Bedrock Core Photographs

EXP Services Inc. www.exp.com
t: +1.613.688.1899 | f: +1.613.225.7337
2650 Queensview Drive, Suite 100
Ottawa, ON K2B 8H6, Canada

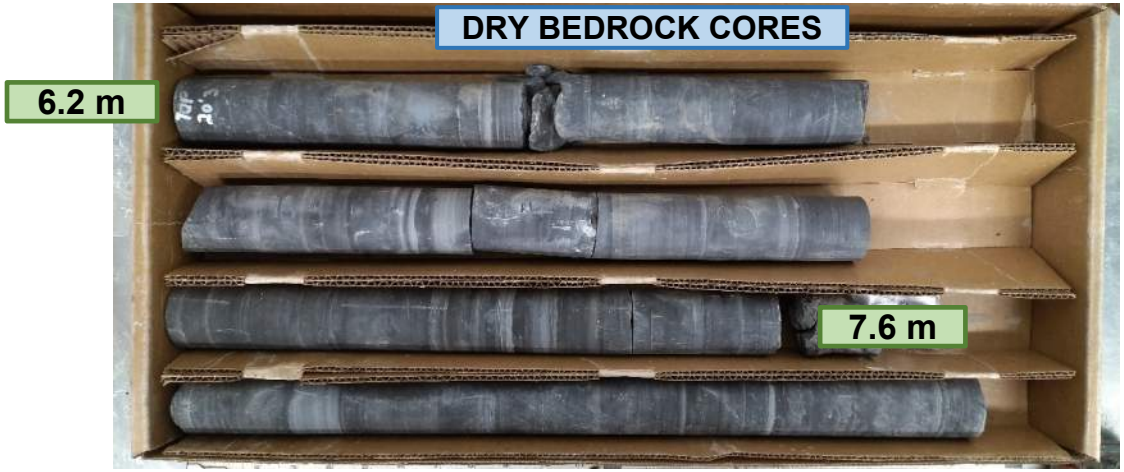
Borehole No:	Core Runs	project	Project N0:
BH23-1	Run 1: 6.7 m - 7.6 m Run 2: 7.6 m - 9.3 m	Geotechnical Investigation 1770 Heatherington Ave, Ottawa, ON	OTT-00257901-A0
Date Cored November 30, 2023		Rock Core Photographs	E1

DRY BEDROCK CORES

WET BEDROCK CORES

EXP Services Inc. www.exp.com
t: +1.613.688.1899 | f: +1.613.225.7337
2650 Queensview Drive, Suite 100
Ottawa, ON K2B 8H6, Canada

Borehole No:	Core Runs	project	Project N0:
BH23-1	Run 3: 9.3 m - 9.8 m	Geotechnical Investigation 1770 Heatherington Ave, Ottawa, ON	OTT-00257901-A0
Date Cored November 30, 2023		Rock Core Photographs	E2



EXP Services Inc. www.exp.com
t: +1.613.688.1899 | f: +1.613.225.7337
2650 Queensview Drive, Suite 100
Ottawa, ON K2B 8H6, Canada

Borehole No:	Core Runs	project	Project N0:
BH23-6	Run 1: 6.2 m - 7.6 m Run 2: 7.6 m - 9.3 m	Geotechnical Investigation 1770 Heatherington Ave, Ottawa, ON	OTT-00257901-A0
Date Cored November 23, 2023		Rock Core Photographs	E3

DRY BEDROCK CORES

WET BEDROCK CORES

EXP Services Inc. www.exp.com
t: +1.613.688.1899 | f: +1.613.225.7337
2650 Queensview Drive, Suite 100
Ottawa, ON K2B 8H6, Canada

Borehole No:	Core Runs	project	Project N0:
BH23-6	Run 2: 7.6 m - 9.3 m	Geotechnical Investigation 1770 Heatherington Ave, Ottawa, ON	OTT-00257901-A0
Date Cored November 23, 2023		Rock Core Photographs	E4

DRY BEDROCK CORES

WET BEDROCK CORES

EXP Services Inc. www.exp.com
t: +1.613.688.1899 | f: +1.613.225.7337
2650 Queensview Drive, Suite 100
Ottawa, ON K2B 8H6, Canada

Borehole No:	Core Runs	project	Project N0:
BH23-9	Run 1: 6.2 m - 7.0 m Run 2: 7.0 m - 8.4 m	Geotechnical Investigation 1770 Heatherington Ave, Ottawa, ON	OTT-00257901-A0
Date Cored November 21, 2023		Rock Core Photographs	E5

DRY BEDROCK CORES

WET BEDROCK CORES

EXP Services Inc. www.exp.com
t: +1.613.688.1899 | f: +1.613.225.7337
2650 Queensview Drive, Suite 100
Ottawa, ON K2B 8H6, Canada

Borehole No:	Core Runs	project	Project N0:
BH23-9	Run 3: 8.4 m - 9.9 m	Geotechnical Investigation 1770 Heatherington Ave, Ottawa, ON	OTT-00257901-A0
Date Cored November 21, 2023		Rock Core Photographs	E6

Appendix F – Liquefaction Analysis Results

Block 1: Borehole No. 23-5

LIQUEFACTION ANALYSIS

(D.P. Coduto (1999) Geotechnical Engineering Principles and Practices)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 23-5

Ground Surface Elev. = 87.5 m

Water Table Depth = 1.8 m

Earthquake Magnitude, M = 6.5

Distance to fault trace, d = 2.0 km

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	N_{60}	$(N_1)_{60}$	%Fine	CRR			CSR				FS_L
									CRR_1 M=7.5	ψ M=6.5	CRR	a_{max}/g in rock	a_{max}/g in soil	r_d	CSR	
0.0	Fill	18.0	0.0	0.0	0.0											
3.2	Organic Cl Si	16.0	51.2	13.7	37.5											
3.2	Si Cl	18.0	51.2	13.7	37.5											
3.2	Si Sa Till, loose to compact	20.0	51.2	13.7	37.5	20	33	15	0.60	1.18	0.71	0.76	0.37	0.98	0.32	2.21
3.6	Si Sa Till, loose to compact	20.0	58.9	17.5	41.4	20	31	15	0.60	1.18	0.71	0.76	0.37	0.97	0.33	2.13
4.0	Si Sa Till, loose to compact	20.0	66.5	21.3	45.3	5	7	15	0.13	1.18	0.15	0.76	0.37	0.97	0.34	0.45
4.4	Si Sa Till, loose to compact	20.0	74.2	25.0	49.2	5	7	15	0.13	1.18	0.15	0.76	0.37	0.97	0.35	0.42
4.7	Si Sa Till, loose to compact	20.0	81.9	28.8	53.1	23	32	15	0.60	1.18	0.71	0.76	0.37	0.96	0.36	1.98
5.1	Si Sa Till, loose to compact	20.0	89.5	32.5	57.0	23	30	15	0.60	1.18	0.71	0.76	0.37	0.96	0.36	1.95
5.5	Si Sa Till, loose to compact	20.0	97.2	36.3	60.9	23	29	15	0.60	1.18	0.71	0.76	0.37	0.96	0.37	1.93
5.6	Shale	21.0	99.3	37.3	62.0											
5.7	Shale	21.0	101.4	38.3	63.1											
5.8	Shale	21.0	103.5	39.2	64.3											

Project No. : OTT-22026647-A0

Date : May, 2024

Prepared By : HW

Checked By : SP

#N/A

LIQUEFACTION ANALYSIS

(Canadian Foundation Engineering Manual, 4E)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 23-5

Ground Surface Elev. = 87.5 m

Earthquake Magnitude, M = 6.5

Water Table Depth = 1.8 m

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	N_{60}	$(N_1)_{60}$	%Fine	CRR				CSR			FS_L
									CRR_1	K_σ	K_m	CRR	a_{max}/g	r_d	CSR	
0.0	Fill	18.0	0.0	0.0	0.0											
3.2	Organic Cl Si	16.0	51.2	13.7	37.5											
3.2	Si Cl	18.0	51.2	13.7	37.5											
3.2	Si Sa Till, loose to compact	20.0	51.2	13.7	37.5	20	26	15	0.60	1.00	1.44	0.87	0.36	0.98	0.31	2.77
3.6	Si Sa Till, loose to compact	20.0	58.9	17.5	41.4	20	26	15	0.60	1.00	1.44	0.87	0.36	0.97	0.32	2.66
4.0	Si Sa Till, loose to compact	20.0	66.5	21.3	45.3	5	6	15	0.10	1.00	1.44	0.14	0.36	0.97	0.33	0.43
4.4	Si Sa Till, loose to compact	20.0	74.2	25.0	49.2	5	6	15	0.10	1.00	1.44	0.14	0.36	0.97	0.34	0.42
4.7	Si Sa Till, loose to compact	20.0	81.9	28.8	53.1	23	28	15	0.60	1.00	1.44	0.87	0.36	0.96	0.35	2.48
5.1	Si Sa Till, loose to compact	20.0	89.5	32.5	57.0	23	27	15	0.60	1.00	1.44	0.87	0.36	0.96	0.35	2.44
5.5	Si Sa Till, loose to compact	20.0	97.2	36.3	60.9	23	27	15	0.60	1.00	1.44	0.87	0.36	0.96	0.36	2.41
5.6	Shale	21.0	99.3	37.3	62.0											
5.7	Shale	21.0	101.4	38.3	63.1											
5.8	Shale	21.0	103.5	39.2	64.3											

Project No. : OTT-22026647-A0

Prepared By : HW

Date : May, 2024

Checked By : SP

#N/A

LIQUEFACTION ANALYSIS
(Canadian Foundation Engineering Manual, 4E)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 23-5

Ground Surface Elev. = 87.5 m

Earthquake Magnitude, M = 6.5

Water Table Depth = 1.8 m

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	N_{60}	$(N_1)_{60}$	%Fine	CSR			Shear Wave Velocity		CRR	FS_L
									a_{max}/g	r_d	CSR	V_s (m/s)	V_{s1} (m/s)		
0.0	Fill	18.0	0.0	0.0	0.0										
3.2	Organic Cl Si	16.0	51.2	13.7	37.5										
3.2	Si Cl	18.0	51.2	13.7	37.5										
3.2	Si Sa Till, loose to compact	20.0	51.2	13.7	37.5	20	26	15	0.36	0.98	0.31	125	171	0.13	0.42
3.6	Si Sa Till, loose to compact	20.0	58.9	17.5	41.4	20	26	15	0.36	0.97	0.32	125	165	0.12	0.37
4.0	Si Sa Till, loose to compact	20.0	66.5	21.3	45.3	5	6	15	0.36	0.97	0.33	125	161	0.10	0.31
4.4	Si Sa Till, loose to compact	20.0	74.2	25.0	49.2	5	6	15	0.36	0.97	0.34	125	156	0.10	0.28
4.7	Si Sa Till, loose to compact	20.0	81.9	28.8	53.1	23	28	15	0.36	0.96	0.35	125	152	0.09	0.25
5.1	Si Sa Till, loose to compact	20.0	89.5	32.5	57.0	23	27	15	0.36	0.96	0.35	125	149	0.08	0.24
5.5	Si Sa Till, loose to compact	20.0	97.2	36.3	60.9	23	27	15	0.36	0.96	0.36	125	145	0.08	0.22
5.6	Shale	21.0	99.3	37.3	62.0										
5.7	Shale	21.0	101.4	38.3	63.1										
5.8	Shale	21.0	103.5	39.2	64.3										

Project No. : OTT-22026647-A0

Prepared By : HW

Date : May, 2024

Checked By : SP

#N/A

Block 2: Borehole No. 24-10

LIQUEFACTION ANALYSIS

(Canadian Foundation Engineering Manual, 4E)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 24-10

Ground Surface Elev. = 87.7 m

Earthquake Magnitude, M = 6.5

Water Table Depth = 2.0 m

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	N_{60}	$(N_1)_{60}$	%Fine	CRR				CSR			FS_L
									CRR_1	K_σ	K_m	CRR	a_{max}/g	r_d	CSR	
0.0	Fill	18.0	0.0	0.0	0.0											
0.8	Organic Cl Si	16.0	12.6	0.0	12.6											
0.9	Si Cl	18.0	14.4	0.0	14.4											
3.7	Si Sa Till, loose to compact	20.0	70.4	16.7	53.8	20	24	15	0.60	1.00	1.44	0.87	0.36	0.97	0.30	2.90
4.2	Si Sa Till, loose to compact	20.0	80.1	21.4	58.7	20	23	15	0.45	1.00	1.44	0.65	0.36	0.97	0.31	2.09
4.7	Si Sa Till, loose to compact	20.0	89.8	26.2	63.6	20	23	15	0.38	1.00	1.44	0.55	0.36	0.96	0.32	1.72
5.1	Si Sa Till, loose to compact	20.0	99.4	30.9	68.5	19	21	15	0.32	1.00	1.44	0.46	0.36	0.96	0.33	1.41
5.6	Si Sa Till, loose to compact	20.0	109.1	35.6	73.5	19	21	15	0.31	1.00	1.44	0.45	0.36	0.96	0.33	1.34
6.1	Si Sa Till, loose to compact	20.0	118.8	40.4	78.4	19	20	15	0.30	1.00	1.44	0.43	0.36	0.95	0.34	1.28
6.6	Si Sa Till, loose to compact	20.0	128.4	45.1	83.3	19	20	15	0.29	1.00	1.44	0.42	0.36	0.95	0.34	1.22
6.6	Shale	21.0	128.4	45.1	83.3											
6.6	Shale	21.0	128.4	45.1	83.3											
6.6	Shale	21.0	128.4	45.1	83.3											

Project No. : OTT-22026647-A0

Prepared By : HW

Date : May, 2024

Checked By : SP

#N/A

LIQUEFACTION ANALYSIS
(Canadian Foundation Engineering Manual, 4E)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 24-10

Ground Surface Elev. = 87.7 m

Earthquake Magnitude, M = 6.5

Water Table Depth = 2.0 m

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	N_{60}	$(N_1)_{60}$	%Fine	CSR			Shear Wave Velocity		CRR	FS_L
									a_{max}/g	r_d	CSR	V_s (m/s)	V_{s1} (m/s)		
0.0	Fill	18.0	0.0	0.0	0.0										
0.8	Organic Cl Si	16.0	12.6	0.0	12.6										
0.9	Si Cl	18.0	14.4	0.0	14.4										
3.7	Si Sa Till, loose to compact	20.0	70.4	16.7	53.8	20	24	15	0.36	0.97	0.30	125	152	0.09	0.30
4.2	Si Sa Till, loose to compact	20.0	80.1	21.4	58.7	20	23	15	0.36	0.97	0.31	125	147	0.09	0.27
4.7	Si Sa Till, loose to compact	20.0	89.8	26.2	63.6	20	23	15	0.36	0.96	0.32	125	143	0.08	0.25
5.1	Si Sa Till, loose to compact	20.0	99.4	30.9	68.5	19	21	15	0.36	0.96	0.33	125	140	0.08	0.23
5.6	Si Sa Till, loose to compact	20.0	109.1	35.6	73.5	19	21	15	0.36	0.96	0.33	125	137	0.07	0.21
6.1	Si Sa Till, loose to compact	20.0	118.8	40.4	78.4	19	20	15	0.36	0.95	0.34	125	134	0.07	0.19
6.6	Si Sa Till, loose to compact	20.0	128.4	45.1	83.3	19	20	15	0.36	0.95	0.34	125	131	0.06	0.18
6.6	Shale	21.0	128.4	45.1	83.3										
6.6	Shale	21.0	128.4	45.1	83.3										
6.6	Shale	21.0	128.4	45.1	83.3										

Project No. : OTT-22026647-A0

Prepared By : HW

Date : May, 2024

Checked By : SP

#N/A

LIQUEFACTION ANALYSIS

(D.P. Coduto (1999) Geotechnical Engineering Principles and Practices)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 24-10

Ground Surface Elev. = 87.7 m

Water Table Depth = 2.0 m

Earthquake Magnitude, M = 6.5

Distance to fault trace, d = 2.0 km

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	N_{60}	$(N_1)_{60}$	%Fine	CRR			CSR				FS_L
									CRR_1 M=7.5	ψ M=6.5	CRR	a_{max}/g in rock	a_{max}/g in soil	r_d	CSR	
0.0	Fill	18.0	0.0	0.0	0.0											
0.8	Organic Cl Si	16.0	12.6	0.0	12.6											
0.9	Si Cl	18.0	14.4	0.0	14.4											
3.7	Si Sa Till, loose to compact	20.0	70.4	16.7	53.8	20	27	15	0.60	1.18	0.71	0.76	0.37	0.97	0.31	2.31
4.2	Si Sa Till, loose to compact	20.0	80.1	21.4	58.7	20	26	15	0.60	1.18	0.71	0.76	0.37	0.97	0.32	2.23
4.7	Si Sa Till, loose to compact	20.0	89.8	26.2	63.6	20	25	15	0.60	1.18	0.71	0.76	0.37	0.96	0.33	2.16
5.1	Si Sa Till, loose to compact	20.0	99.4	30.9	68.5	19	23	15	0.38	1.18	0.45	0.76	0.37	0.96	0.34	1.34
5.6	Si Sa Till, loose to compact	20.0	109.1	35.6	73.5	19	22	15	0.35	1.18	0.41	0.76	0.37	0.96	0.34	1.21
6.1	Si Sa Till, loose to compact	20.0	118.8	40.4	78.4	19	21	15	0.33	1.18	0.39	0.76	0.37	0.95	0.35	1.12
6.6	Si Sa Till, loose to compact	20.0	128.4	45.1	83.3	19	21	15	0.31	1.18	0.37	0.76	0.37	0.95	0.35	1.04
6.6	Shale	21.0	128.4	45.1	83.3											
6.6	Shale	21.0	128.4	45.1	83.3											
6.6	Shale	21.0	128.4	45.1	83.3											

Project No. : OTT-22026647-A0

Prepared By : HW

Date : May, 2024

Checked By : SP

#N/A

Block 3: Borehole No. 23-2

LIQUEFACTION ANALYSIS

(Canadian Foundation Engineering Manual, 4E)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 23-2

Ground Surface Elev. = 87.9 m

Earthquake Magnitude, M = 6.5

Water Table Depth = 2.2 m

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	N_{60}	$(N_1)_{60}$	%Fine	CRR				CSR			FS_L
									CRR_1	K_σ	K_m	CRR	a_{max}/g	r_d	CSR	
0.0	Fill	18.0	0.0	0.0	0.0											
0.8	Organic Cl Si	16.0	12.5	0.0	12.5											
0.9	Si Cl	18.0	14.3	0.0	14.3											
2.2	Si Sa Till, loose to compact	20.0	40.3	0.0	40.3	7	9	15	0.14	1.00	1.44	0.19	0.36	0.98	0.23	0.84
2.7	Si Sa Till, loose to compact	20.0	51.6	5.6	46.1	7	9	15	0.13	1.00	1.44	0.19	0.36	0.98	0.26	0.73
3.3	Si Sa Till, loose to compact	20.0	62.9	11.1	51.8	4	5	15	0.08	1.00	1.44	0.12	0.36	0.97	0.28	0.42
3.9	Si Sa Till, loose to compact	20.0	74.3	16.7	57.6	4	5	15	0.08	1.00	1.44	0.12	0.36	0.97	0.29	0.39
4.4	Si Sa Till, loose to compact	20.0	85.6	22.2	63.4	4	5	15	0.08	1.00	1.44	0.12	0.36	0.97	0.31	0.38
5.0	Si Sa Till, loose to compact	20.0	96.9	27.8	69.2	18	20	15	0.30	1.00	1.44	0.43	0.36	0.96	0.32	1.34
5.6	Si Sa Till, loose to compact	20.0	108.3	33.4	74.9	18	20	15	0.30	1.00	1.44	0.43	0.36	0.96	0.32	1.33
5.8	Shale	21.0	113.2	35.6	77.5											
6.0	Shale	21.0	118.1	37.9	80.1											
6.3	Shale	21.0	123.0	40.2	82.8											

Project No. : OTT-22026647-A0

Prepared By : HW

Date : May, 2024

Checked By : SP

#N/A

LIQUEFACTION ANALYSIS
(Canadian Foundation Engineering Manual, 4E)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 23-2

Ground Surface Elev. = 87.9 m

Earthquake Magnitude, M = 6.5

Water Table Depth = 2.2 m

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	N_{60}	$(N_1)_{60}$	%Fine	CSR			Shear Wave Velocity		CRR	FS_L
									a_{max}/g	r_d	CSR	V_s (m/s)	V_{s1} (m/s)		
0.0	Fill	18.0	0.0	0.0	0.0										
0.8	Organic Cl Si	16.0	12.5	0.0	12.5										
0.9	Si Cl	18.0	14.3	0.0	14.3										
2.2	Si Sa Till, loose to compact	20.0	40.3	0.0	40.3	7	9	15	0.36	0.98	0.23	125	167	0.11	0.48
2.7	Si Sa Till, loose to compact	20.0	51.6	5.6	46.1	7	9	15	0.36	0.98	0.26	125	160	0.10	0.39
3.3	Si Sa Till, loose to compact	20.0	62.9	11.1	51.8	4	5	15	0.36	0.97	0.28	125	154	0.09	0.32
3.9	Si Sa Till, loose to compact	20.0	74.3	16.7	57.6	4	5	15	0.36	0.97	0.29	125	148	0.08	0.27
4.4	Si Sa Till, loose to compact	20.0	85.6	22.2	63.4	4	5	15	0.36	0.97	0.31	125	144	0.08	0.24
5.0	Si Sa Till, loose to compact	20.0	96.9	27.8	69.2	18	20	15	0.36	0.96	0.32	125	139	0.07	0.22
5.6	Si Sa Till, loose to compact	20.0	108.3	33.4	74.9	18	20	15	0.36	0.96	0.32	125	136	0.07	0.21
5.8	Shale	21.0	113.2	35.6	77.5										
6.0	Shale	21.0	118.1	37.9	80.1										
6.3	Shale	21.0	123.0	40.2	82.8										

Project No. : OTT-22026647-A0

Prepared By : HW

Date : May, 2024

Checked By : SP

#N/A

LIQUEFACTION ANALYSIS
(Canadian Foundation Engineering Manual, 4E)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 23-2

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	$(N_1)_{60}$	CSR	Liquefied Shear Strength						Post-Liquefaction Settlement		
								Ratio			Residual Strength					
								max.	aver.	min.	max. (kPa)	aver. (kPa)	min. (kPa)	ε	Δs (mm)	s (mm)
0.0	Fill	18.0	0.0	0.0	0.0											
0.8	Organic Cl Si	16.0	12.5	0.0	12.5											
0.9	Si Cl	18.0	14.3	0.0	14.3											
2.2	Si Sa Till, loose to compact	20.0	40.3	0.0	40.3	9	0.23	0.130	0.099	0.068	5.2	4.0	2.7			
2.7	Si Sa Till, loose to compact	20.0	51.6	5.6	46.1	9	0.26	0.130	0.099	0.068	6.0	4.6	3.1	3.8%	21.3	21.3
3.3	Si Sa Till, loose to compact	20.0	62.9	11.1	51.8	5	0.28	0.100	0.069	0.038	5.2	3.6	2.0	5.7%	32.3	53.6
3.9	Si Sa Till, loose to compact	20.0	74.3	16.7	57.6	5	0.29	0.100	0.069	0.038	5.8	4.0	2.2	5.9%	33.4	87.0
4.4	Si Sa Till, loose to compact	20.0	85.6	22.2	63.4	5	0.31	0.100	0.069	0.038	6.3	4.4	2.4	6.0%	34.0	121.0
5.0	Si Sa Till, loose to compact	20.0	96.9	27.8	69.2	20	0.32	0.214	0.183	0.152	14.8	12.6	10.5	1.8%	10.2	131.2
5.6	Si Sa Till, loose to compact	20.0	108.3	33.4	74.9	20	0.32	0.214	0.183	0.152	16.0	13.7	11.4	2.0%	11.3	142.5
5.8	Shale	21.0	113.2	35.6	77.5											
6.0	Shale	21.0	118.1	37.9	80.1											
6.3	Shale	21.0	123.0	40.2	82.8											

Total Post-Liquefaction Settlement 143 mm

Overall Strain 4.2%

Residual Strength 2 - 16 kPa

Project No. : OTT-22026647-A0

Date : May, 2024

Prepared By : HW

Checked By : SP

#N/A

LIQUEFACTION ANALYSIS

(D.P. Coduto (1999) Geotechnical Engineering Principles and Practices)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 23-2

Ground Surface Elev. = 87.9 m

Water Table Depth = 2.2 m

Earthquake Magnitude, M = 6.5

Distance to fault trace, d = 2.0 km

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	N_{60}	$(N_1)_{60}$	%Fine	CRR			CSR				FS_L
									CRR_1 M=7.5	ψ M=6.5	CRR	a_{max}/g in rock	a_{max}/g in soil	r_d	CSR	
0.0	Fill	18.0	0.0	0.0	0.0											
0.8	Organic Cl Si	16.0	12.5	0.0	12.5											
0.9	Si Cl	18.0	14.3	0.0	14.3											
2.2	Si Sa Till, loose to compact	20.0	40.3	0.0	40.3	7	11	15	0.17	1.18	0.19	0.76	0.37	0.98	0.24	0.82
2.7	Si Sa Till, loose to compact	20.0	51.6	5.6	46.1	7	10	15	0.16	1.18	0.18	0.76	0.37	0.98	0.26	0.69
3.3	Si Sa Till, loose to compact	20.0	62.9	11.1	51.8	4	6	15	0.10	1.18	0.12	0.76	0.37	0.97	0.28	0.41
3.9	Si Sa Till, loose to compact	20.0	74.3	16.7	57.6	4	5	15	0.10	1.18	0.11	0.76	0.37	0.97	0.30	0.37
4.4	Si Sa Till, loose to compact	20.0	85.6	22.2	63.4	4	5	15	0.10	1.18	0.11	0.76	0.37	0.97	0.31	0.36
5.0	Si Sa Till, loose to compact	20.0	96.9	27.8	69.2	18	22	15	0.34	1.18	0.40	0.76	0.37	0.96	0.32	1.24
5.6	Si Sa Till, loose to compact	20.0	108.3	33.4	74.9	18	21	15	0.31	1.18	0.37	0.76	0.37	0.96	0.33	1.10
5.8	Shale	21.0	113.2	35.6	77.5											
6.0	Shale	21.0	118.1	37.9	80.1											
6.3	Shale	21.0	123.0	40.2	82.8											

Project No. : OTT-22026647-A0

Prepared By : HW

Date : May, 2024

Checked By : SP

#N/A

Block 6: Borehole No. 23-3

LIQUEFACTION ANALYSIS

(Canadian Foundation Engineering Manual, 4E)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 23-3

Ground Surface Elev. = 87.6 m

Earthquake Magnitude, M = 6.5

Water Table Depth = 1.9 m

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	N_{60}	$(N_1)_{60}$	%Fine	CRR				CSR			FS_L
									CRR_1	K_σ	K_m	CRR	a_{max}/g	r_d	CSR	
0.0	Fill	18.0	0.0	0.0	0.0											
0.9	Organic Cl Si	16.0	14.4	0.0	14.4											
0.9	Si Cl	18.0	14.4	0.0	14.4											
2.8	Si Sa Till, loose to compact	20.0	52.4	8.8	43.6	4	5	15	0.09	1.00	1.44	0.12	0.36	0.98	0.28	0.44
3.5	Si Sa Till, loose to compact	20.0	66.1	15.5	50.5	4	5	15	0.09	1.00	1.44	0.13	0.36	0.97	0.30	0.42
4.2	Si Sa Till, loose to compact	20.0	79.7	22.2	57.5	13	15	15	0.22	1.00	1.44	0.32	0.36	0.97	0.32	1.01
4.8	Si Sa Till, loose to compact	20.0	93.4	28.9	64.5	13	15	15	0.21	1.00	1.44	0.30	0.36	0.96	0.33	0.92
5.5	Si Sa Till, loose to compact	20.0	107.1	35.6	71.4	67	74	15	0.60	1.00	1.44	0.87	0.36	0.96	0.34	2.57
6.2	Si Sa Till, loose to compact	20.0	120.7	42.3	78.4	67	72	15	0.60	1.00	1.44	0.87	0.36	0.95	0.34	2.51
6.9	Si Sa Till, loose to compact	20.0	134.4	49.1	85.3	67	70	15	0.60	1.00	1.44	0.87	0.36	0.95	0.35	2.47
6.9	Shale	21.0	134.4	49.1	85.3											
6.9	Shale	21.0	134.4	49.1	85.3											
6.9	Shale	21.0	134.4	49.1	85.3											

Project No. : OTT-22026647-A0

Prepared By : HW

Date : May, 2024

Checked By : SP

LIQUEFACTION ANALYSIS

(Canadian Foundation Engineering Manual, 4E)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 23-3

Ground Surface Elev. = 87.6 m

Earthquake Magnitude, M = 6.5

Water Table Depth = 1.9 m

Depth	Soil Classification	γ	σ_v	μ	σ_v'	N_{60}	$(N_1)_{60}$	%Fine	CSR			Shear Wave Velocity		CRR	FS_L
									a_{max}/g	r_d	CSR	V_s	V_{s1}		
z (m)		(kN/m^3)	(kPa)	(kPa)	(kPa)							(m/s)	(m/s)		
0.0	Fill	18.0	0.0	0.0	0.0										
0.9	Organic Cl Si	16.0	14.4	0.0	14.4										
0.9	Si Cl	18.0	14.4	0.0	14.4										
2.8	Si Sa Till, loose to compact	20.0	52.4	8.8	43.6	4	5	15	0.36	0.98	0.28	125	163	0.11	0.40
3.5	Si Sa Till, loose to compact	20.0	66.1	15.5	50.5	4	5	15	0.36	0.97	0.30	125	155	0.10	0.32
4.2	Si Sa Till, loose to compact	20.0	79.7	22.2	57.5	13	15	15	0.36	0.97	0.32	125	148	0.09	0.27
4.8	Si Sa Till, loose to compact	20.0	93.4	28.9	64.5	13	15	15	0.36	0.96	0.33	125	143	0.08	0.24
5.5	Si Sa Till, loose to compact	20.0	107.1	35.6	71.4	67	74	15	0.36	0.96	0.34	125	138	0.07	0.21
6.2	Si Sa Till, loose to compact	20.0	120.7	42.3	78.4	67	72	15	0.36	0.95	0.34	125	134	0.07	0.19
6.9	Si Sa Till, loose to compact	20.0	134.4	49.1	85.3	67	70	15	0.36	0.95	0.35	125	130	0.06	0.18
6.9	Shale	21.0	134.4	49.1	85.3										
6.9	Shale	21.0	134.4	49.1	85.3										
6.9	Shale	21.0	134.4	49.1	85.3										

Project No. : OTT-22026647-A0

Prepared By : HW

Date : May, 2024

Checked By : SP

LIQUEFACTION ANALYSIS

(D.P. Coduto (1999) Geotechnical Engineering Principles and Practices)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 23-3

Ground Surface Elev. = 87.6 m

Water Table Depth = 1.9 m

Earthquake Magnitude, M = 6.5

Distance to fault trace, d = 2.0 km

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	N_{60}	$(N_1)_{60}$	%Fine	CRR			CSR				FS_L
									CRR_1 M=7.5	ψ M=6.5	CRR	a_{max}/g in rock	a_{max}/g in soil	r_d	CSR	
0.0	Fill	18.0	0.0	0.0	0.0											
0.9	Organic Cl Si	16.0	14.4	0.0	14.4											
0.9	Si Cl	18.0	14.4	0.0	14.4											
2.8	Si Sa Till, loose to compact	20.0	52.4	8.8	43.6	4	6	15	0.11	1.18	0.13	0.76	0.37	0.98	0.28	0.46
3.5	Si Sa Till, loose to compact	20.0	66.1	15.5	50.5	4	6	15	0.10	1.18	0.12	0.76	0.37	0.97	0.31	0.39
4.2	Si Sa Till, loose to compact	20.0	79.7	22.2	57.5	13	17	15	0.25	1.18	0.30	0.76	0.37	0.97	0.32	0.91
4.8	Si Sa Till, loose to compact	20.0	93.4	28.9	64.5	13	16	15	0.24	1.18	0.28	0.76	0.37	0.96	0.34	0.84
5.5	Si Sa Till, loose to compact	20.0	107.1	35.6	71.4	67	79	15	0.60	1.18	0.71	0.76	0.37	0.96	0.35	2.05
6.2	Si Sa Till, loose to compact	20.0	120.7	42.3	78.4	67	76	15	0.60	1.18	0.71	0.76	0.37	0.95	0.35	2.01
6.9	Si Sa Till, loose to compact	20.0	134.4	49.1	85.3	67	73	15	0.60	1.18	0.71	0.76	0.37	0.95	0.36	1.97
6.9	Shale	21.0	134.4	49.1	85.3											
6.9	Shale	21.0	134.4	49.1	85.3											
6.9	Shale	21.0	134.4	49.1	85.3											

Project No. : OTT-22026647-A0

Date : May, 2024

Prepared By : HW

Checked By : SP

Block 8: Borehole No. 24-12

LIQUEFACTION ANALYSIS

(Canadian Foundation Engineering Manual, 4E)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 24-12

Ground Surface Elev. = 87.5 m

Earthquake Magnitude, M = 6.5

Water Table Depth = 1.8 m

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	N_{60}	$(N_1)_{60}$	%Fine	CRR				CSR			FS_L
									CRR_1	K_σ	K_m	CRR	a_{max}/g	r_d	CSR	
0.0	Fill	18.0	0.0	0.0	0.0											
1.0	Organic Cl Si	16.0	15.8	0.0	15.8											
1.0	Si Cl	18.0	15.8	0.0	15.8											
4.0	Si Sa Till, loose to compact	20.0	75.8	21.6	54.3	3	4	15	0.07	1.00	1.44	0.10	0.36	0.97	0.32	0.32
4.4	Si Sa Till, loose to compact	20.0	84.5	25.8	58.7	3	3	15	0.07	1.00	1.44	0.10	0.36	0.97	0.33	0.31
4.9	Si Sa Till, loose to compact	20.0	93.2	30.1	63.1	5	6	15	0.09	1.00	1.44	0.13	0.36	0.96	0.33	0.39
5.3	Si Sa Till, loose to compact	20.0	101.8	34.3	67.5	5	6	15	0.09	1.00	1.44	0.13	0.36	0.96	0.34	0.38
5.7	Si Sa Till, loose to compact	20.0	110.5	38.6	71.9	5	5	15	0.09	1.00	1.44	0.13	0.36	0.96	0.34	0.38
6.2	Si Sa Till, loose to compact	20.0	119.2	42.8	76.3	5	5	15	0.09	1.00	1.44	0.13	0.36	0.95	0.35	0.37
6.6	Si Sa Till, loose to compact	20.0	127.8	47.1	80.8	95	101	15	0.60	1.00	1.44	0.87	0.36	0.95	0.35	2.45
6.6	Shale	21.0	127.8	47.1	80.8											
6.6	Shale	21.0	127.8	47.1	80.8											
6.6	Shale	21.0	127.8	47.1	80.8											

Project No. : OTT-22026647-A0

Prepared By : HW

Date : May, 2024

Checked By : SP

#N/A

LIQUEFACTION ANALYSIS
(Canadian Foundation Engineering Manual, 4E)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 24-12

Ground Surface Elev. = 87.5 m

Earthquake Magnitude, M = 6.5

Water Table Depth = 1.8 m

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	N_{60}	$(N_1)_{60}$	%Fine	CSR			Shear Wave Velocity		CRR	FS_L
									a_{max}/g	r_d	CSR	V_s (m/s)	V_{s1} (m/s)		
0.0	Fill	18.0	0.0	0.0	0.0										
1.0	Organic Cl Si	16.0	15.8	0.0	15.8										
1.0	Si Cl	18.0	15.8	0.0	15.8										
4.0	Si Sa Till, loose to compact	20.0	75.8	21.6	54.3	3	4	15	0.36	0.97	0.32	125	151	0.09	0.28
4.4	Si Sa Till, loose to compact	20.0	84.5	25.8	58.7	3	3	15	0.36	0.97	0.33	125	147	0.09	0.26
4.9	Si Sa Till, loose to compact	20.0	93.2	30.1	63.1	5	6	15	0.36	0.96	0.33	125	144	0.08	0.24
5.3	Si Sa Till, loose to compact	20.0	101.8	34.3	67.5	5	6	15	0.36	0.96	0.34	125	141	0.08	0.22
5.7	Si Sa Till, loose to compact	20.0	110.5	38.6	71.9	5	5	15	0.36	0.96	0.34	125	138	0.07	0.20
6.2	Si Sa Till, loose to compact	20.0	119.2	42.8	76.3	5	5	15	0.36	0.95	0.35	125	135	0.07	0.19
6.6	Si Sa Till, loose to compact	20.0	127.8	47.1	80.8	95	101	15	0.36	0.95	0.35	125	132	0.06	0.18
6.6	Shale	21.0	127.8	47.1	80.8										
6.6	Shale	21.0	127.8	47.1	80.8										
6.6	Shale	21.0	127.8	47.1	80.8										

Project No. : OTT-22026647-A0

Prepared By : HW

Date : May, 2024

Checked By : SP

#N/A

LIQUEFACTION ANALYSIS
(Canadian Foundation Engineering Manual, 4E)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 24-12

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	$(N_1)_{60}$	CSR	Liquefied Shear Strength						Post-Liquefaction Settlement		
								Ratio			Residual Strength					
								max.	aver.	min.	max. (kPa)	aver. (kPa)	min. (kPa)	ε	Δs (mm)	s (mm)
0.0	Fill	18.0	0.0	0.0	0.0											
1.0	Organic Cl Si	16.0	15.8	0.0	15.8											
1.0	Si Cl	18.0	15.8	0.0	15.8											
4.0	Si Sa Till, loose to compact	20.0	75.8	21.6	54.3	4	0.32	0.092	0.061	0.030	5.0	3.3	1.6			
4.4	Si Sa Till, loose to compact	20.0	84.5	25.8	58.7	3	0.33	0.085	0.054	0.023	5.0	3.2	1.3	7.0%	30.3	30.3
4.9	Si Sa Till, loose to compact	20.0	93.2	30.1	63.1	6	0.33	0.107	0.076	0.045	6.8	4.8	2.9	5.5%	23.8	54.2
5.3	Si Sa Till, loose to compact	20.0	101.8	34.3	67.5	6	0.34	0.107	0.076	0.045	7.3	5.2	3.1	5.6%	24.3	78.4
5.7	Si Sa Till, loose to compact	20.0	110.5	38.6	71.9	5	0.34	0.100	0.069	0.038	7.2	5.0	2.7	5.7%	24.7	103.1
6.2	Si Sa Till, loose to compact	20.0	119.2	42.8	76.3	5	0.35	0.100	0.069	0.038	7.6	5.3	2.9	5.8%	25.1	128.3
6.6	Si Sa Till, loose to compact	20.0	127.8	47.1	80.8	101	0.35	0.828	0.797	0.766	66.9	64.4	61.8	0.0%	0.0	128.3
6.6	Shale	21.0	127.8	47.1	80.8											
6.6	Shale	21.0	127.8	47.1	80.8											
6.6	Shale	21.0	127.8	47.1	80.8											

Total Post-Liquefaction Settlement **128 mm**

Overall Strain **4.9%**

Residual Strength **1 - 67 kPa**

Project No. : OTT-22026647-A0

Date : May, 2024

Prepared By : HW

Checked By : SP

#N/A

LIQUEFACTION ANALYSIS

(D.P. Coduto (1999) Geotechnical Engineering Principles and Practices)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 24-12

Ground Surface Elev. = 87.5 m

Water Table Depth = 1.8 m

Earthquake Magnitude, M = 6.5

Distance to fault trace, d = 2.0 km

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	N_{60}	$(N_1)_{60}$	%Fine	CRR			CSR				FS_L
									CRR_1 M=7.5	ψ M=6.5	CRR	a_{max}/g in rock	a_{max}/g in soil	r_d	CSR	
0.0	Fill	18.0	0.0	0.0	0.0											
1.0	Organic Cl Si	16.0	15.8	0.0	15.8											
1.0	Si Cl	18.0	15.8	0.0	15.8											
4.0	Si Sa Till, loose to compact	20.0	75.8	21.6	54.3	3	4	15	0.09	1.18	0.10	0.76	0.37	0.97	0.33	0.31
4.4	Si Sa Till, loose to compact	20.0	84.5	25.8	58.7	3	4	15	0.09	1.18	0.10	0.76	0.37	0.97	0.33	0.30
4.9	Si Sa Till, loose to compact	20.0	93.2	30.1	63.1	5	6	15	0.11	1.18	0.13	0.76	0.37	0.96	0.34	0.38
5.3	Si Sa Till, loose to compact	20.0	101.8	34.3	67.5	5	6	15	0.11	1.18	0.13	0.76	0.37	0.96	0.35	0.37
5.7	Si Sa Till, loose to compact	20.0	110.5	38.6	71.9	5	6	15	0.10	1.18	0.12	0.76	0.37	0.96	0.35	0.33
6.2	Si Sa Till, loose to compact	20.0	119.2	42.8	76.3	5	6	15	0.10	1.18	0.12	0.76	0.37	0.95	0.36	0.33
6.6	Si Sa Till, loose to compact	20.0	127.8	47.1	80.8	95	106	15	0.60	1.18	0.71	0.76	0.37	0.95	0.36	1.96
6.6	Shale	21.0	127.8	47.1	80.8											
6.6	Shale	21.0	127.8	47.1	80.8											
6.6	Shale	21.0	127.8	47.1	80.8											

Project No. : OTT-22026647-A0

Prepared By : HW

Date : May, 2024

Checked By : SP

#N/A

Block 10: Borehole No. 23-4

LIQUEFACTION ANALYSIS

(Canadian Foundation Engineering Manual, 4E)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 23-4

Ground Surface Elev. = 87.3 m

Earthquake Magnitude, M = 6.5

Water Table Depth = 1.6 m

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	N_{60}	$(N_1)_{60}$	%Fine	CRR				CSR			FS_L
									CRR_1	K_σ	K_m	CRR	a_{max}/g	r_d	CSR	
0.0	Fill	18.0	0.0	0.0	0.0											
0.7	Organic Cl Si	16.0	11.5	0.0	11.5											
0.7	Si Cl	18.0	11.5	0.0	11.5											
4.3	Si Sa Till, loose to compact	20.0	83.5	26.5	57.0	2	2	15	0.07	1.00	1.44	0.10	0.36	0.97	0.33	0.30
4.6	Si Sa Till, loose to compact	20.0	89.5	29.4	60.1	2	2	15	0.07	1.00	1.44	0.10	0.36	0.96	0.34	0.30
4.9	Si Sa Till, loose to compact	20.0	95.5	32.4	63.1	2	2	15	0.07	1.00	1.44	0.10	0.36	0.96	0.34	0.30
5.2	Si Sa Till, loose to compact	20.0	101.5	35.3	66.2	2	2	15	0.07	1.00	1.44	0.10	0.36	0.96	0.35	0.29
5.5	Si Sa Till, loose to compact	20.0	107.5	38.3	69.3	2	2	15	0.07	1.00	1.44	0.10	0.36	0.96	0.35	0.29
5.8	Si Sa Till, loose to compact	20.0	113.5	41.2	72.3	2	2	15	0.07	1.00	1.44	0.10	0.36	0.96	0.35	0.29
6.1	Si Sa Till, loose to compact	20.0	119.5	44.1	75.4	2	2	15	0.07	1.00	1.44	0.10	0.36	0.95	0.35	0.28
6.1	Shale	21.0	119.5	44.1	75.4											
6.1	Shale	21.0	119.5	44.1	75.4											
6.1	Shale	21.0	119.5	44.1	75.4											

Project No. : OTT-22026647-A0

Prepared By : HW

Date : May, 2024

Checked By : SP

#N/A

LIQUEFACTION ANALYSIS
(Canadian Foundation Engineering Manual, 4E)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 23-4

Ground Surface Elev. = 87.3 m

Earthquake Magnitude, M = 6.5

Water Table Depth = 1.6 m

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	N_{60}	$(N_1)_{60}$	%Fine	CSR			Shear Wave Velocity		CRR	FS_L
									a_{max}/g	r_d	CSR	V_s (m/s)	V_{s1} (m/s)		
0.0	Fill	18.0	0.0	0.0	0.0										
0.7	Organic Cl Si	16.0	11.5	0.0	11.5										
0.7	Si Cl	18.0	11.5	0.0	11.5										
4.3	Si Sa Till, loose to compact	20.0	83.5	26.5	57.0	2	2	15	0.36	0.97	0.33	125	149	0.09	0.26
4.6	Si Sa Till, loose to compact	20.0	89.5	29.4	60.1	2	2	15	0.36	0.96	0.34	125	146	0.08	0.24
4.9	Si Sa Till, loose to compact	20.0	95.5	32.4	63.1	2	2	15	0.36	0.96	0.34	125	144	0.08	0.23
5.2	Si Sa Till, loose to compact	20.0	101.5	35.3	66.2	2	2	15	0.36	0.96	0.35	125	141	0.08	0.22
5.5	Si Sa Till, loose to compact	20.0	107.5	38.3	69.3	2	2	15	0.36	0.96	0.35	125	139	0.07	0.21
5.8	Si Sa Till, loose to compact	20.0	113.5	41.2	72.3	2	2	15	0.36	0.96	0.35	125	137	0.07	0.20
6.1	Si Sa Till, loose to compact	20.0	119.5	44.1	75.4	2	2	15	0.36	0.95	0.35	125	135	0.07	0.19
6.1	Shale	21.0	119.5	44.1	75.4										
6.1	Shale	21.0	119.5	44.1	75.4										
6.1	Shale	21.0	119.5	44.1	75.4										

Project No. : OTT-22026647-A0

Prepared By : HW

Date : May, 2024

Checked By : SP

#N/A

LIQUEFACTION ANALYSIS
(Canadian Foundation Engineering Manual, 4E)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 23-4

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	$(N_1)_{60}$	CSR	Liquefied Shear Strength						Post-Liquefaction Settlement		
								Ratio			Residual Strength					
								max.	aver.	min.	max. (kPa)	aver. (kPa)	min. (kPa)	ε	Δs (mm)	s (mm)
0.0	Fill	18.0	0.0	0.0	0.0											
0.7	Organic Cl Si	16.0	11.5	0.0	11.5											
0.7	Si Cl	18.0	11.5	0.0	11.5											
4.3	Si Sa Till, loose to compact	20.0	83.5	26.5	57.0	2	0.33	0.077	0.046	0.015	4.4	2.6	0.9			
4.6	Si Sa Till, loose to compact	20.0	89.5	29.4	60.1	2	0.34	0.077	0.046	0.015	4.6	2.8	0.9	9.1%	27.3	27.3
4.9	Si Sa Till, loose to compact	20.0	95.5	32.4	63.1	2	0.34	0.077	0.046	0.015	4.9	2.9	1.0	9.2%	27.6	54.9
5.2	Si Sa Till, loose to compact	20.0	101.5	35.3	66.2	2	0.35	0.077	0.046	0.015	5.1	3.1	1.0	9.3%	27.9	82.8
5.5	Si Sa Till, loose to compact	20.0	107.5	38.3	69.3	2	0.35	0.077	0.046	0.015	5.3	3.2	1.1	9.4%	28.2	111.0
5.8	Si Sa Till, loose to compact	20.0	113.5	41.2	72.3	2	0.35	0.077	0.046	0.015	5.6	3.3	1.1	9.5%	28.5	139.5
6.1	Si Sa Till, loose to compact	20.0	119.5	44.1	75.4	2	0.35	0.077	0.046	0.015	5.8	3.5	1.1	9.6%	28.8	168.3
6.1	Shale	21.0	119.5	44.1	75.4											
6.1	Shale	21.0	119.5	44.1	75.4											
6.1	Shale	21.0	119.5	44.1	75.4											

Total Post-Liquefaction Settlement **168 mm**

Overall Strain **9.3%**

Residual Strength **1 - 6 kPa**

Project No. : OTT-22026647-A0

Date : May, 2024

Prepared By : HW

Checked By : SP

#N/A

LIQUEFACTION ANALYSIS

(D.P. Coduto (1999) Geotechnical Engineering Principles and Practices)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 23-4

Ground Surface Elev. = 87.3 m

Water Table Depth = 1.6 m

Earthquake Magnitude, M = 6.5

Distance to fault trace, d = 2.0 km

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	N_{60}	$(N_1)_{60}$	%Fine	CRR			CSR				FS_L
									CRR_1 M=7.5	ψ M=6.5	CRR	a_{max}/g in rock	a_{max}/g in soil	r_d	CSR	
0.0	Fill	18.0	0.0	0.0	0.0											
0.7	Organic Cl Si	16.0	11.5	0.0	11.5											
0.7	Si Cl	18.0	11.5	0.0	11.5											
4.3	Si Sa Till, loose to compact	20.0	83.5	26.5	57.0	2	3	15	0.07	1.18	0.08	0.76	0.37	0.97	0.34	0.24
4.6	Si Sa Till, loose to compact	20.0	89.5	29.4	60.1	2	3	15	0.07	1.18	0.08	0.76	0.37	0.96	0.35	0.24
4.9	Si Sa Till, loose to compact	20.0	95.5	32.4	63.1	2	3	15	0.07	1.18	0.08	0.76	0.37	0.96	0.35	0.24
5.2	Si Sa Till, loose to compact	20.0	101.5	35.3	66.2	2	2	15	0.07	1.18	0.08	0.76	0.37	0.96	0.35	0.23
5.5	Si Sa Till, loose to compact	20.0	107.5	38.3	69.3	2	2	15	0.07	1.18	0.08	0.76	0.37	0.96	0.36	0.23
5.8	Si Sa Till, loose to compact	20.0	113.5	41.2	72.3	2	2	15	0.07	1.18	0.08	0.76	0.37	0.96	0.36	0.23
6.1	Si Sa Till, loose to compact	20.0	119.5	44.1	75.4	2	2	15	0.07	1.18	0.08	0.76	0.37	0.95	0.36	0.23
6.1	Shale	21.0	119.5	44.1	75.4											
6.1	Shale	21.0	119.5	44.1	75.4											
6.1	Shale	21.0	119.5	44.1	75.4											

Project No. : OTT-22026647-A0

Prepared By : HW

Date : May, 2024

Checked By : SP

#N/A

Block 12: Borehole No. 24-13

LIQUEFACTION ANALYSIS

(Canadian Foundation Engineering Manual, 4E)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 24-13

Ground Surface Elev. = 86.9 m

Earthquake Magnitude, M = 6.5

Water Table Depth = 1.2 m

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	N_{60}	$(N_1)_{60}$	%Fine	CRR				CSR			FS_L
									CRR_1	K_σ	K_m	CRR	a_{max}/g	r_d	CSR	
0.0	Fill	18.0	0.0	0.0	0.0											
0.9	Organic Cl Si	16.0	14.9	0.0	14.9											
0.9	Si Cl	18.0	14.9	0.0	14.9											
4.2	Si Sa Till, loose to compact	20.0	80.9	29.4	51.5	7	8	15	0.13	1.00	1.44	0.19	0.36	0.97	0.36	0.53
4.7	Si Sa Till, loose to compact	20.0	89.9	33.8	56.0	7	8	15	0.13	1.00	1.44	0.19	0.36	0.96	0.36	0.52
5.1	Si Sa Till, loose to compact	20.0	98.9	38.3	60.6	7	8	15	0.12	1.00	1.44	0.17	0.36	0.96	0.37	0.47
5.6	Si Sa Till, loose to compact	20.0	107.9	42.7	65.2	7	8	15	0.12	1.00	1.44	0.17	0.36	0.96	0.37	0.47
6.0	Si Sa Till, loose to compact	20.0	116.9	47.1	69.8	7	8	15	0.12	1.00	1.44	0.17	0.36	0.95	0.37	0.46
6.5	Si Sa Till, loose to compact	20.0	125.9	51.5	74.4	36	39	15	0.60	1.00	1.44	0.87	0.36	0.95	0.38	2.29
6.9	Si Sa Till, loose to compact	20.0	134.9	55.9	79.0	36	38	15	0.60	1.00	1.44	0.87	0.36	0.95	0.38	2.28
6.9	Shale	21.0	134.9	55.9	79.0											
6.9	Shale	21.0	134.9	55.9	79.0											
6.9	Shale	21.0	134.9	55.9	79.0											

Project No. : OTT-22026647-A0

Prepared By : HW

Date : May, 2024

Checked By : SP

#N/A

LIQUEFACTION ANALYSIS
(Canadian Foundation Engineering Manual, 4E)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 24-13

Ground Surface Elev. = 86.9 m

Earthquake Magnitude, M = 6.5

Water Table Depth = 1.2 m

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	N_{60}	$(N_1)_{60}$	%Fine	CSR			Shear Wave Velocity		CRR	FS_L
									a_{max}/g	r_d	CSR	V_s (m/s)	V_{s1} (m/s)		
0.0	Fill	18.0	0.0	0.0	0.0										
0.9	Organic Cl Si	16.0	14.9	0.0	14.9										
0.9	Si Cl	18.0	14.9	0.0	14.9										
4.2	Si Sa Till, loose to compact	20.0	80.9	29.4	51.5	7	8	15	0.36	0.97	0.36	125	154	0.09	0.25
4.7	Si Sa Till, loose to compact	20.0	89.9	33.8	56.0	7	8	15	0.36	0.96	0.36	125	150	0.09	0.23
5.1	Si Sa Till, loose to compact	20.0	98.9	38.3	60.6	7	8	15	0.36	0.96	0.37	125	146	0.08	0.22
5.6	Si Sa Till, loose to compact	20.0	107.9	42.7	65.2	7	8	15	0.36	0.96	0.37	125	142	0.08	0.20
6.0	Si Sa Till, loose to compact	20.0	116.9	47.1	69.8	7	8	15	0.36	0.95	0.37	125	139	0.07	0.19
6.5	Si Sa Till, loose to compact	20.0	125.9	51.5	74.4	36	39	15	0.36	0.95	0.38	125	136	0.07	0.18
6.9	Si Sa Till, loose to compact	20.0	134.9	55.9	79.0	36	38	15	0.36	0.95	0.38	125	133	0.06	0.17
6.9	Shale	21.0	134.9	55.9	79.0										
6.9	Shale	21.0	134.9	55.9	79.0										
6.9	Shale	21.0	134.9	55.9	79.0										

Project No. : OTT-22026647-A0

Prepared By : HW

Date : May, 2024

Checked By : SP

#N/A

LIQUEFACTION ANALYSIS
(Canadian Foundation Engineering Manual, 4E)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 24-13

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	$(N_1)_{60}$	CSR	Liquefied Shear Strength – Ratio max.	Ratio aver.	Ratio min.	Residual Strength max. (kPa)	Residual Strength aver. (kPa)	Residual Strength min. (kPa)	Post-Liquefaction Settlement ε	Δs (mm)	s (mm)
0.0	Fill	18.0	0.0	0.0	0.0											
0.9	Organic Cl Si	16.0	14.9	0.0	14.9											
0.9	Si Cl	18.0	14.9	0.0	14.9											
4.2	Si Sa Till, loose to compact	20.0	80.9	29.4	51.5	8	0.36	0.123	0.092	0.061	6.3	4.7	3.1			
4.7	Si Sa Till, loose to compact	20.0	89.9	33.8	56.0	8	0.36	0.123	0.092	0.061	6.9	5.1	3.4	4.3%	19.4	19.4
5.1	Si Sa Till, loose to compact	20.0	98.9	38.3	60.6	8	0.37	0.123	0.092	0.061	7.4	5.6	3.7	4.4%	19.8	39.2
5.6	Si Sa Till, loose to compact	20.0	107.9	42.7	65.2	8	0.37	0.123	0.092	0.061	8.0	6.0	4.0	4.5%	20.3	59.4
6.0	Si Sa Till, loose to compact	20.0	116.9	47.1	69.8	8	0.37	0.123	0.092	0.061	8.6	6.4	4.2	4.6%	20.7	80.1
6.5	Si Sa Till, loose to compact	20.0	125.9	51.5	74.4	39	0.38	0.358	0.327	0.296	26.6	24.3	22.0	0.0%	0.0	80.1
6.9	Si Sa Till, loose to compact	20.0	134.9	55.9	79.0	38	0.38	0.350	0.319	0.288	27.7	25.2	22.8	0.0%	0.0	80.1
6.9	Shale	21.0	134.9	55.9	79.0											
6.9	Shale	21.0	134.9	55.9	79.0											
6.9	Shale	21.0	134.9	55.9	79.0											

Total Post-Liquefaction Settlement **80 mm**

Overall Strain **3.0%**

Residual Strength **3 - 28 kPa**

Project No. : OTT-22026647-A0

Date : May, 2024

Prepared By : HW

Checked By : SP

#N/A

LIQUEFACTION ANALYSIS

(D.P. Coduto (1999) Geotechnical Engineering Principles and Practices)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 24-13

Ground Surface Elev. = 86.9 m

Water Table Depth = 1.2 m

Earthquake Magnitude, M = 6.5

Distance to fault trace, d = 2.0 km

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	N_{60}	$(N_1)_{60}$	%Fine	CRR			CSR				FS_L
									CRR_1 M=7.5	ψ M=6.5	CRR	a_{max}/g in rock	a_{max}/g in soil	r_d	CSR	
0.0	Fill	18.0	0.0	0.0	0.0											
0.9	Organic Cl Si	16.0	14.9	0.0	14.9											
0.9	Si Cl	18.0	14.9	0.0	14.9											
4.2	Si Sa Till, loose to compact	20.0	80.9	29.4	51.5	7	10	15	0.15	1.18	0.18	0.76	0.37	0.97	0.37	0.48
4.7	Si Sa Till, loose to compact	20.0	89.9	33.8	56.0	7	9	15	0.14	1.18	0.17	0.76	0.37	0.96	0.37	0.44
5.1	Si Sa Till, loose to compact	20.0	98.9	38.3	60.6	7	9	15	0.14	1.18	0.17	0.76	0.37	0.96	0.38	0.44
5.6	Si Sa Till, loose to compact	20.0	107.9	42.7	65.2	7	9	15	0.14	1.18	0.17	0.76	0.37	0.96	0.38	0.43
6.0	Si Sa Till, loose to compact	20.0	116.9	47.1	69.8	7	8	15	0.13	1.18	0.15	0.76	0.37	0.95	0.38	0.40
6.5	Si Sa Till, loose to compact	20.0	125.9	51.5	74.4	36	42	15	0.60	1.18	0.71	0.76	0.37	0.95	0.39	1.83
6.9	Si Sa Till, loose to compact	20.0	134.9	55.9	79.0	36	41	15	0.60	1.18	0.71	0.76	0.37	0.95	0.39	1.82
6.9	Shale	21.0	134.9	55.9	79.0											
6.9	Shale	21.0	134.9	55.9	79.0											
6.9	Shale	21.0	134.9	55.9	79.0											

Project No. : OTT-22026647-A0

Prepared By : HW

Date : May, 2024

Checked By : SP

#N/A

Block 13: Borehole No. 23-7

LIQUEFACTION ANALYSIS

(Canadian Foundation Engineering Manual, 4E)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 23-7

Ground Surface Elev. = 87.1 m

Earthquake Magnitude, M = 6.5

Water Table Depth = 1.4 m

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	N_{60}	$(N_1)_{60}$	%Fine	CRR				CSR			FS_L
									CRR_1	K_σ	K_m	CRR	a_{max}/g	r_d	CSR	
0.0	Fill	18.0	0.0	0.0	0.0											
1.5	Organic Cl Si	16.0	23.5	1.0	22.5											
1.6	Si Cl	18.0	25.3	2.0	23.4											
4.3	Si Sa Till, loose to compact	20.0	79.3	28.4	50.9	4	5	15	0.08	1.00	1.44	0.12	0.36	0.97	0.35	0.33
4.5	Si Sa Till, loose to compact	20.0	83.7	30.6	53.1	4	5	15	0.08	1.00	1.44	0.12	0.36	0.97	0.36	0.32
4.7	Si Sa Till, loose to compact	20.0	88.0	32.7	55.3	4	5	15	0.08	1.00	1.44	0.12	0.36	0.96	0.36	0.32
4.9	Si Sa Till, loose to compact	20.0	92.3	34.8	57.5	4	5	15	0.08	1.00	1.44	0.12	0.36	0.96	0.36	0.32
5.1	Si Sa Till, loose to compact	20.0	96.7	37.0	59.7	4	5	15	0.08	1.00	1.44	0.12	0.36	0.96	0.36	0.32
5.4	Si Sa Till, loose to compact	20.0	101.0	39.1	61.9	4	5	15	0.08	1.00	1.44	0.12	0.36	0.96	0.37	0.31
5.6	Si Sa Till, loose to compact	20.0	105.3	41.2	64.1	4	5	15	0.08	1.00	1.44	0.12	0.36	0.96	0.37	0.31
5.6	Shale	21.0	105.3	41.2	64.1											
5.6	Shale	21.0	105.3	41.2	64.1											
5.6	Shale	21.0	105.3	41.2	64.1											

Project No. : OTT-22026647-A0

Prepared By : HW

Date : May, 2024

Checked By : SP

#N/A

LIQUEFACTION ANALYSIS
(Canadian Foundation Engineering Manual, 4E)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 23-7

Ground Surface Elev. = 87.1 m

Earthquake Magnitude, M = 6.5

Water Table Depth = 1.4 m

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	N_{60}	$(N_1)_{60}$	%Fine	CSR			Shear Wave Velocity		CRR	FS_L
									a_{max}/g	r_d	CSR	V_s (m/s)	V_{s1} (m/s)		
0.0	Fill	18.0	0.0	0.0	0.0										
1.5	Organic Cl Si	16.0	23.5	1.0	22.5										
1.6	Si Cl	18.0	25.3	2.0	23.4										
4.3	Si Sa Till, loose to compact	20.0	79.3	28.4	50.9	4	5	15	0.36	0.97	0.35	125	154	0.09	0.25
4.5	Si Sa Till, loose to compact	20.0	83.7	30.6	53.1	4	5	15	0.36	0.97	0.36	125	152	0.09	0.25
4.7	Si Sa Till, loose to compact	20.0	88.0	32.7	55.3	4	5	15	0.36	0.96	0.36	125	150	0.09	0.24
4.9	Si Sa Till, loose to compact	20.0	92.3	34.8	57.5	4	5	15	0.36	0.96	0.36	125	148	0.08	0.23
5.1	Si Sa Till, loose to compact	20.0	96.7	37.0	59.7	4	5	15	0.36	0.96	0.36	125	146	0.08	0.22
5.4	Si Sa Till, loose to compact	20.0	101.0	39.1	61.9	4	5	15	0.36	0.96	0.37	125	145	0.08	0.21
5.6	Si Sa Till, loose to compact	20.0	105.3	41.2	64.1	4	5	15	0.36	0.96	0.37	125	143	0.08	0.21
5.6	Shale	21.0	105.3	41.2	64.1										
5.6	Shale	21.0	105.3	41.2	64.1										
5.6	Shale	21.0	105.3	41.2	64.1										

Project No. : OTT-22026647-A0

Prepared By : HW

Date : May, 2024

Checked By : SP

#N/A

LIQUEFACTION ANALYSIS
(Canadian Foundation Engineering Manual, 4E)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 23-7

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	$(N_1)_{60}$	CSR	Liquefied Shear Strength						Post-Liquefaction Settlement		
								Ratio			Residual Strength					
								max.	aver.	min.	max. (kPa)	aver. (kPa)	min. (kPa)	ε	Δs (mm)	s (mm)
0.0	Fill	18.0	0.0	0.0	0.0											
1.5	Organic Cl Si	16.0	23.5	1.0	22.5											
1.6	Si Cl	18.0	25.3	2.0	23.4											
4.3	Si Sa Till, loose to compact	20.0	79.3	28.4	50.9	5	0.35	0.100	0.069	0.038	5.1	3.5	1.9			
4.5	Si Sa Till, loose to compact	20.0	83.7	30.6	53.1	5	0.36	0.100	0.069	0.038	5.3	3.7	2.0	6.0%	13.0	13.0
4.7	Si Sa Till, loose to compact	20.0	88.0	32.7	55.3	5	0.36	0.100	0.069	0.038	5.5	3.8	2.1	6.0%	13.0	26.0
4.9	Si Sa Till, loose to compact	20.0	92.3	34.8	57.5	5	0.36	0.100	0.069	0.038	5.7	4.0	2.2	6.1%	13.2	39.2
5.1	Si Sa Till, loose to compact	20.0	96.7	37.0	59.7	5	0.36	0.100	0.069	0.038	6.0	4.1	2.3	6.1%	13.2	52.4
5.4	Si Sa Till, loose to compact	20.0	101.0	39.1	61.9	5	0.37	0.100	0.069	0.038	6.2	4.3	2.3	6.1%	13.2	65.6
5.6	Si Sa Till, loose to compact	20.0	105.3	41.2	64.1	5	0.37	0.100	0.069	0.038	6.4	4.4	2.4	6.2%	13.4	79.1
5.6	Shale	21.0	105.3	41.2	64.1											
5.6	Shale	21.0	105.3	41.2	64.1											
5.6	Shale	21.0	105.3	41.2	64.1											

Total Post-Liquefaction Settlement **79 mm**

Overall Strain **6.1%**

Residual Strength **2 - 6 kPa**

Project No. : OTT-22026647-A0

Date : May, 2024

Prepared By : HW

Checked By : SP

#N/A

LIQUEFACTION ANALYSIS

(D.P. Coduto (1999) Geotechnical Engineering Principles and Practices)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 23-7

Ground Surface Elev. = 87.1 m

Water Table Depth = 1.4 m

Earthquake Magnitude, M = 6.5

Distance to fault trace, d = 2.0 km

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	N_{60}	$(N_1)_{60}$	%Fine	CRR			CSR				FS_L
									CRR_1 M=7.5	ψ M=6.5	CRR	a_{max}/g in rock	a_{max}/g in soil	r_d	CSR	
0.0	Fill	18.0	0.0	0.0	0.0											
1.5	Organic Cl Si	16.0	23.5	1.0	22.5											
1.6	Si Cl	18.0	25.3	2.0	23.4											
4.3	Si Sa Till, loose to compact	20.0	79.3	28.4	50.9	4	6	15	0.11	1.18	0.13	0.76	0.37	0.97	0.36	0.36
4.5	Si Sa Till, loose to compact	20.0	83.7	30.6	53.1	4	5	15	0.10	1.18	0.12	0.76	0.37	0.97	0.37	0.32
4.7	Si Sa Till, loose to compact	20.0	88.0	32.7	55.3	4	5	15	0.10	1.18	0.12	0.76	0.37	0.96	0.37	0.32
4.9	Si Sa Till, loose to compact	20.0	92.3	34.8	57.5	4	5	15	0.10	1.18	0.12	0.76	0.37	0.96	0.37	0.32
5.1	Si Sa Till, loose to compact	20.0	96.7	37.0	59.7	4	5	15	0.10	1.18	0.12	0.76	0.37	0.96	0.37	0.32
5.4	Si Sa Till, loose to compact	20.0	101.0	39.1	61.9	4	5	15	0.10	1.18	0.12	0.76	0.37	0.96	0.38	0.31
5.6	Si Sa Till, loose to compact	20.0	105.3	41.2	64.1	4	5	15	0.10	1.18	0.12	0.76	0.37	0.96	0.38	0.31
5.6	Shale	21.0	105.3	41.2	64.1											
5.6	Shale	21.0	105.3	41.2	64.1											
5.6	Shale	21.0	105.3	41.2	64.1											

Project No. : OTT-22026647-A0

Prepared By : HW

Date : May, 2024

Checked By : SP

#N/A

Block 14: Borehole Nos. 23-9 and 24-14

LIQUEFACTION ANALYSIS

(Canadian Foundation Engineering Manual, 4E)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 23-9

Ground Surface Elev. = 86.5 m

Earthquake Magnitude, M = 6.5

Water Table Depth = 0.8 m

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	N_{60}	$(N_1)_{60}$	%Fine	CRR				CSR			FS_L
									CRR_1	K_σ	K_m	CRR	a_{max}/g	r_d	CSR	
0.0	Fill	18.0	0.0	0.0	0.0											
0.3	Organic Cl Si	16.0	4.6	0.0	4.6											
0.4	Si Cl	18.0	6.4	0.0	6.4											
3.8	Si Sa Till, loose to compact	20.0	74.4	29.4	45.0	2	3	15	0.07	1.00	1.44	0.09	0.36	0.97	0.38	0.25
4.2	Si Sa Till, loose to compact	20.0	82.4	33.4	49.1	2	2	15	0.07	1.00	1.44	0.09	0.36	0.97	0.38	0.25
4.6	Si Sa Till, loose to compact	20.0	90.4	37.3	53.2	2	2	15	0.07	1.00	1.44	0.09	0.36	0.96	0.39	0.24
5.0	Si Sa Till, loose to compact	20.0	98.4	41.2	57.2	24	28	15	0.60	1.00	1.44	0.87	0.36	0.96	0.39	2.23
5.4	Si Sa Till, loose to compact	20.0	106.4	45.1	61.3	24	28	15	0.60	1.00	1.44	0.87	0.36	0.96	0.39	2.22
5.8	Si Sa Till, loose to compact	20.0	114.4	49.1	65.4	24	27	15	0.60	1.00	1.44	0.87	0.36	0.96	0.39	2.20
6.2	Si Sa Till, loose to compact	20.0	122.4	53.0	69.5	24	27	15	0.60	1.00	1.44	0.87	0.36	0.95	0.39	2.20
7.4	Shale	21.0	148.3	65.1	83.3											
8.7	Shale	21.0	174.2	77.2	97.1											
9.9	Shale	21.0	200.1	89.3	110.9											

Project No. : OTT-22026647-A0

Prepared By : HW

Date : May, 2024

Checked By : SP

#N/A

LIQUEFACTION ANALYSIS
(Canadian Foundation Engineering Manual, 4E)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 23-9

Ground Surface Elev. = 86.5 m

Earthquake Magnitude, M = 6.5

Water Table Depth = 0.8 m

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	N_{60}	$(N_1)_{60}$	%Fine	CSR			Shear Wave Velocity		CRR	FS_L
									a_{max}/g	r_d	CSR	V_s (m/s)	V_{s1} (m/s)		
0.0	Fill	18.0	0.0	0.0	0.0										
0.3	Organic Cl Si	16.0	4.6	0.0	4.6										
0.4	Si Cl	18.0	6.4	0.0	6.4										
3.8	Si Sa Till, loose to compact	20.0	74.4	29.4	45.0	2	3	15	0.36	0.97	0.38	125	161	0.11	0.28
4.2	Si Sa Till, loose to compact	20.0	82.4	33.4	49.1	2	2	15	0.36	0.97	0.38	125	156	0.10	0.26
4.6	Si Sa Till, loose to compact	20.0	90.4	37.3	53.2	2	2	15	0.36	0.96	0.39	125	152	0.09	0.23
5.0	Si Sa Till, loose to compact	20.0	98.4	41.2	57.2	24	28	15	0.36	0.96	0.39	125	149	0.09	0.22
5.4	Si Sa Till, loose to compact	20.0	106.4	45.1	61.3	24	28	15	0.36	0.96	0.39	125	145	0.08	0.20
5.8	Si Sa Till, loose to compact	20.0	114.4	49.1	65.4	24	27	15	0.36	0.96	0.39	125	142	0.08	0.19
6.2	Si Sa Till, loose to compact	20.0	122.4	53.0	69.5	24	27	15	0.36	0.95	0.39	125	139	0.07	0.19
7.4	Shale	21.0	148.3	65.1	83.3										
8.7	Shale	21.0	174.2	77.2	97.1										
9.9	Shale	21.0	200.1	89.3	110.9										

Project No. : OTT-22026647-A0

Prepared By : HW

Date : May, 2024

Checked By : SP

#N/A

LIQUEFACTION ANALYSIS

(D.P. Coduto (1999) Geotechnical Engineering Principles and Practices)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 23-9

Ground Surface Elev. = 86.5 m

Water Table Depth = 0.8 m

Earthquake Magnitude, M = 6.5

Distance to fault trace, d = 2.0 km

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	N_{60}	$(N_1)_{60}$	%Fine	CRR			CSR				FS_L
									CRR_1 M=7.5	ψ M=6.5	CRR	a_{max}/g in rock	a_{max}/g in soil	r_d	CSR	
0.0	Fill	18.0	0.0	0.0	0.0											
0.3	Organic Cl Si	16.0	4.6	0.0	4.6											
0.4	Si Cl	18.0	6.4	0.0	6.4											
3.8	Si Sa Till, loose to compact	20.0	74.4	29.4	45.0	2	3	15	0.08	1.18	0.09	0.76	0.37	0.97	0.39	0.24
4.2	Si Sa Till, loose to compact	20.0	82.4	33.4	49.1	2	3	15	0.08	1.18	0.09	0.76	0.37	0.97	0.39	0.24
4.6	Si Sa Till, loose to compact	20.0	90.4	37.3	53.2	2	3	15	0.08	1.18	0.09	0.76	0.37	0.96	0.39	0.24
5.0	Si Sa Till, loose to compact	20.0	98.4	41.2	57.2	24	32	15	0.60	1.18	0.71	0.76	0.37	0.96	0.40	1.78
5.4	Si Sa Till, loose to compact	20.0	106.4	45.1	61.3	24	31	15	0.60	1.18	0.71	0.76	0.37	0.96	0.40	1.77
5.8	Si Sa Till, loose to compact	20.0	114.4	49.1	65.4	24	30	15	0.60	1.18	0.71	0.76	0.37	0.96	0.40	1.76
6.2	Si Sa Till, loose to compact	20.0	122.4	53.0	69.5	24	29	15	0.60	1.18	0.71	0.76	0.37	0.95	0.40	1.75
7.4	Shale	21.0	148.3	65.1	83.3											
8.7	Shale	21.0	174.2	77.2	97.1											
9.9	Shale	21.0	200.1	89.3	110.9											

Project No. : OTT-22026647-A0

Date : May, 2024

Prepared By : HW

Checked By : SP

#N/A

LIQUEFACTION ANALYSIS

(Canadian Foundation Engineering Manual, 4E)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 24-14

Ground Surface Elev. = 86.7 m

Earthquake Magnitude, M = 6.5

Water Table Depth = 1.0 m

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	N_{60}	$(N_1)_{60}$	%Fine	CRR				CSR			FS_L
									CRR_1	K_σ	K_m	CRR	a_{max}/g	r_d	CSR	
0.0	Fill	18.0	0.0	0.0	0.0											
0.9	Organic Cl Si	16.0	14.2	0.0	14.2											
0.9	Si Cl	18.0	14.2	0.0	14.2											
4.0	Si Sa Till, loose to compact	20.0	76.2	29.4	46.8	10	12	15	0.18	1.00	1.44	0.25	0.36	0.97	0.37	0.68
4.4	Si Sa Till, loose to compact	20.0	83.9	33.2	50.7	10	12	15	0.18	1.00	1.44	0.25	0.36	0.97	0.38	0.67
4.8	Si Sa Till, loose to compact	20.0	91.6	37.0	54.6	34	40	15	0.60	1.00	1.44	0.87	0.36	0.96	0.38	2.28
5.1	Si Sa Till, loose to compact	20.0	99.2	40.7	58.5	34	40	15	0.60	1.00	1.44	0.87	0.36	0.96	0.38	2.26
5.5	Si Sa Till, loose to compact	20.0	106.9	44.5	62.4	34	39	15	0.60	1.00	1.44	0.87	0.36	0.96	0.38	2.25
5.9	Si Sa Till, loose to compact	20.0	114.6	48.2	66.3	300	338	15	0.60	1.00	1.44	0.87	0.36	0.95	0.39	2.24
6.3	Si Sa Till, loose to compact	20.0	122.2	52.0	70.2	300	332	15	0.60	1.00	1.44	0.87	0.36	0.95	0.39	2.23
6.3	Shale	21.0	122.2	52.0	70.2											
6.3	Shale	21.0	122.2	52.0	70.2											
6.3	Shale	21.0	122.2	52.0	70.2											

Project No. : OTT-22026647-A0

Prepared By : HW

Date : May, 2024

Checked By : SP

#N/A

LIQUEFACTION ANALYSIS
(Canadian Foundation Engineering Manual, 4E)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 24-14

Ground Surface Elev. = 86.7 m

Earthquake Magnitude, M = 6.5

Water Table Depth = 1.0 m

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	N_{60}	$(N_1)_{60}$	%Fine	CSR			Shear Wave Velocity		CRR	FS_L
									a_{max}/g	r_d	CSR	V_s (m/s)	V_{s1} (m/s)		
0.0	Fill	18.0	0.0	0.0	0.0										
0.9	Organic Cl Si	16.0	14.2	0.0	14.2										
0.9	Si Cl	18.0	14.2	0.0	14.2										
4.0	Si Sa Till, loose to compact	20.0	76.2	29.4	46.8	10	12	15	0.36	0.97	0.37	125	159	0.10	0.27
4.4	Si Sa Till, loose to compact	20.0	83.9	33.2	50.7	10	12	15	0.36	0.97	0.38	125	155	0.10	0.25
4.8	Si Sa Till, loose to compact	20.0	91.6	37.0	54.6	34	40	15	0.36	0.96	0.38	125	151	0.09	0.24
5.1	Si Sa Till, loose to compact	20.0	99.2	40.7	58.5	34	40	15	0.36	0.96	0.38	125	147	0.09	0.22
5.5	Si Sa Till, loose to compact	20.0	106.9	44.5	62.4	34	39	15	0.36	0.96	0.38	125	144	0.08	0.21
5.9	Si Sa Till, loose to compact	20.0	114.6	48.2	66.3	300	338	15	0.36	0.95	0.39	125	141	0.08	0.19
6.3	Si Sa Till, loose to compact	20.0	122.2	52.0	70.2	300	332	15	0.36	0.95	0.39	125	139	0.07	0.18
6.3	Shale	21.0	122.2	52.0	70.2										
6.3	Shale	21.0	122.2	52.0	70.2										
6.3	Shale	21.0	122.2	52.0	70.2										

Project No. : OTT-22026647-A0

Prepared By : HW

Date : May, 2024

Checked By : SP

#N/A

LIQUEFACTION ANALYSIS

(D.P. Coduto (1999) Geotechnical Engineering Principles and Practices)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 24-14

Ground Surface Elev. = 86.7 m

Water Table Depth = 1.0 m

Earthquake Magnitude, M = 6.5

Distance to fault trace, d = 2.0 km

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	N_{60}	$(N_1)_{60}$	%Fine	CRR			CSR				FS_L
									CRR_1 M=7.5	ψ M=6.5	CRR	a_{max}/g in rock	a_{max}/g in soil	r_d	CSR	
0.0	Fill	18.0	0.0	0.0	0.0											
0.9	Organic Cl Si	16.0	14.2	0.0	14.2											
0.9	Si Cl	18.0	14.2	0.0	14.2											
4.0	Si Sa Till, loose to compact	20.0	76.2	29.4	46.8	10	15	15	0.21	1.18	0.25	0.76	0.37	0.97	0.38	0.65
4.4	Si Sa Till, loose to compact	20.0	83.9	33.2	50.7	10	14	15	0.20	1.18	0.24	0.76	0.37	0.97	0.38	0.61
4.8	Si Sa Till, loose to compact	20.0	91.6	37.0	54.6	34	46	15	0.60	1.18	0.71	0.76	0.37	0.96	0.39	1.82
5.1	Si Sa Till, loose to compact	20.0	99.2	40.7	58.5	34	44	15	0.60	1.18	0.71	0.76	0.37	0.96	0.39	1.81
5.5	Si Sa Till, loose to compact	20.0	106.9	44.5	62.4	34	43	15	0.60	1.18	0.71	0.76	0.37	0.96	0.39	1.80
5.9	Si Sa Till, loose to compact	20.0	114.6	48.2	66.3	300	368	15	0.60	1.18	0.71	0.76	0.37	0.95	0.40	1.79
6.3	Si Sa Till, loose to compact	20.0	122.2	52.0	70.2	300	358	15	0.60	1.18	0.71	0.76	0.37	0.95	0.40	1.78
6.3	Shale	21.0	122.2	52.0	70.2											
6.3	Shale	21.0	122.2	52.0	70.2											
6.3	Shale	21.0	122.2	52.0	70.2											

Project No. : OTT-22026647-A0

Date : May, 2024

Prepared By : HW

Checked By : SP

#N/A

Block 15: Borehole Nos. 23-6 and 24-15

LIQUEFACTION ANALYSIS

(Canadian Foundation Engineering Manual, 4E)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 23-6

Ground Surface Elev. = 87.2 m

Earthquake Magnitude, M = 6.5

Water Table Depth = 1.5 m

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	N_{60}	$(N_1)_{60}$	%Fine	CRR				CSR			FS_L
									CRR_1	K_σ	K_m	CRR	a_{max}/g	r_d	CSR	
0.0	Fill	18.0	0.0	0.0	0.0											
0.9	Organic Cl Si	16.0	15.0	0.0	15.0											
0.9	Si Cl	18.0	15.0	0.0	15.0											
2.8	Si Sa Till, loose to compact	20.0	53.0	12.8	40.3	8	10	15	0.15	1.00	1.44	0.22	0.36	0.98	0.30	0.72
3.4	Si Sa Till, loose to compact	20.0	64.4	18.3	46.1	8	10	15	0.15	1.00	1.44	0.21	0.36	0.97	0.32	0.65
4.0	Si Sa Till, loose to compact	20.0	75.7	23.9	51.8	3	4	15	0.07	1.00	1.44	0.10	0.36	0.97	0.33	0.30
4.5	Si Sa Till, loose to compact	20.0	87.0	29.4	57.6	3	4	15	0.07	1.00	1.44	0.10	0.36	0.97	0.34	0.29
5.1	Si Sa Till, loose to compact	20.0	98.4	35.0	63.4	9	10	15	0.15	1.00	1.44	0.22	0.36	0.96	0.35	0.62
5.7	Si Sa Till, loose to compact	20.0	109.7	40.5	69.2	21	23	15	0.42	1.00	1.44	0.61	0.36	0.96	0.36	1.70
6.2	Si Sa Till, loose to compact	20.0	121.0	46.1	74.9	21	23	15	0.39	1.00	1.44	0.56	0.36	0.95	0.36	1.56
7.3	Shale	21.0	142.7	56.2	86.5											
8.3	Shale	21.0	164.4	66.4	98.1											
9.3	Shale	21.0	186.1	76.5	109.6											

Project No. : OTT-22026647-A0

Prepared By : HW

Date : May, 2024

Checked By : SP

#N/A

LIQUEFACTION ANALYSIS
(Canadian Foundation Engineering Manual, 4E)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 23-6

Ground Surface Elev. = 87.2 m

Earthquake Magnitude, M = 6.5

Water Table Depth = 1.5 m

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	N_{60}	$(N_1)_{60}$	%Fine	CSR			Shear Wave Velocity		CRR	FS_L
									a_{max}/g	r_d	CSR	V_s (m/s)	V_{s1} (m/s)		
0.0	Fill	18.0	0.0	0.0	0.0										
0.9	Organic Cl Si	16.0	15.0	0.0	15.0										
0.9	Si Cl	18.0	15.0	0.0	15.0										
2.8	Si Sa Till, loose to compact	20.0	53.0	12.8	40.3	8	10	15	0.36	0.98	0.30	125	167	0.11	0.36
3.4	Si Sa Till, loose to compact	20.0	64.4	18.3	46.1	8	10	15	0.36	0.97	0.32	125	160	0.10	0.31
4.0	Si Sa Till, loose to compact	20.0	75.7	23.9	51.8	3	4	15	0.36	0.97	0.33	125	154	0.09	0.27
4.5	Si Sa Till, loose to compact	20.0	87.0	29.4	57.6	3	4	15	0.36	0.97	0.34	125	148	0.08	0.23
5.1	Si Sa Till, loose to compact	20.0	98.4	35.0	63.4	9	10	15	0.36	0.96	0.35	125	144	0.08	0.21
5.7	Si Sa Till, loose to compact	20.0	109.7	40.5	69.2	21	23	15	0.36	0.96	0.36	125	139	0.07	0.21
6.2	Si Sa Till, loose to compact	20.0	121.0	46.1	74.9	21	23	15	0.36	0.95	0.36	125	136	0.07	0.19
7.3	Shale	21.0	142.7	56.2	86.5										
8.3	Shale	21.0	164.4	66.4	98.1										
9.3	Shale	21.0	186.1	76.5	109.6										

Project No. : OTT-22026647-A0

Prepared By : HW

Date : May, 2024

Checked By : SP

#N/A

LIQUEFACTION ANALYSIS
(Canadian Foundation Engineering Manual, 4E)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 23-6

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	$(N_1)_{60}$	CSR	Liquefied Shear Strength						Post-Liquefaction Settlement		
								Ratio			Residual Strength					
								max.	aver.	min.	max. (kPa)	aver. (kPa)	min. (kPa)	ε	Δs (mm)	s (mm)
0.0	Fill	18.0	0.0	0.0	0.0											
0.9	Organic Cl Si	16.0	15.0	0.0	15.0											
0.9	Si Cl	18.0	15.0	0.0	15.0											
2.8	Si Sa Till, loose to compact	20.0	53.0	12.8	40.3	10	0.30	0.138	0.107	0.076	5.6	4.3	3.1			
3.4	Si Sa Till, loose to compact	20.0	64.4	18.3	46.1	10	0.32	0.138	0.107	0.076	6.3	4.9	3.5	3.7%	21.0	21.0
4.0	Si Sa Till, loose to compact	20.0	75.7	23.9	51.8	4	0.33	0.092	0.061	0.030	4.8	3.2	1.6	6.9%	39.1	60.1
4.5	Si Sa Till, loose to compact	20.0	87.0	29.4	57.6	4	0.34	0.092	0.061	0.030	5.3	3.5	1.7	7.0%	39.7	99.7
5.1	Si Sa Till, loose to compact	20.0	98.4	35.0	63.4	10	0.35	0.138	0.107	0.076	8.7	6.8	4.8	3.7%	21.0	120.7
5.7	Si Sa Till, loose to compact	20.0	109.7	40.5	69.2	23	0.36	0.236	0.205	0.174	16.4	14.2	12.1	1.6%	9.1	129.8
6.2	Si Sa Till, loose to compact	20.0	121.0	46.1	74.9	23	0.36	0.236	0.205	0.174	17.7	15.4	13.1	1.7%	9.6	139.4
7.3	Shale	21.0	142.7	56.2	86.5											
8.3	Shale	21.0	164.4	66.4	98.1											
9.3	Shale	21.0	186.1	76.5	109.6											

Total Post-Liquefaction Settlement **139 mm**

Overall Strain **4.1%**

Residual Strength **2 - 18 kPa**

Project No. : OTT-22026647-A0

Date : May, 2024

Prepared By : HW

Checked By : SP

#N/A

LIQUEFACTION ANALYSIS

(D.P. Coduto (1999) Geotechnical Engineering Principles and Practices)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 23-6

Ground Surface Elev. = 87.2 m

Water Table Depth = 1.5 m

Earthquake Magnitude, M = 6.5

Distance to fault trace, d = 2.0 km

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	N_{60}	$(N_1)_{60}$	%Fine	CRR			CSR				FS_L
									CRR_1 M=7.5	ψ M=6.5	CRR	a_{max}/g in rock	a_{max}/g in soil	r_d	CSR	
0.0	Fill	18.0	0.0	0.0	0.0											
0.9	Organic Cl Si	16.0	15.0	0.0	15.0											
0.9	Si Cl	18.0	15.0	0.0	15.0											
2.8	Si Sa Till, loose to compact	20.0	53.0	12.8	40.3	8	13	15	0.19	1.18	0.22	0.76	0.37	0.98	0.31	0.72
3.4	Si Sa Till, loose to compact	20.0	64.4	18.3	46.1	8	12	15	0.18	1.18	0.21	0.76	0.37	0.97	0.33	0.65
4.0	Si Sa Till, loose to compact	20.0	75.7	23.9	51.8	3	4	15	0.09	1.18	0.11	0.76	0.37	0.97	0.34	0.31
4.5	Si Sa Till, loose to compact	20.0	87.0	29.4	57.6	3	4	15	0.09	1.18	0.11	0.76	0.37	0.97	0.35	0.30
5.1	Si Sa Till, loose to compact	20.0	98.4	35.0	63.4	9	11	15	0.17	1.18	0.20	0.76	0.37	0.96	0.36	0.56
5.7	Si Sa Till, loose to compact	20.0	109.7	40.5	69.2	21	25	15	0.50	1.18	0.59	0.76	0.37	0.96	0.36	1.62
6.2	Si Sa Till, loose to compact	20.0	121.0	46.1	74.9	21	24	15	0.43	1.18	0.51	0.76	0.37	0.95	0.37	1.37
7.3	Shale	21.0	142.7	56.2	86.5											
8.3	Shale	21.0	164.4	66.4	98.1											
9.3	Shale	21.0	186.1	76.5	109.6											

Project No. : OTT-22026647-A0

Date : May, 2024

Prepared By : HW

Checked By : SP

#N/A

LIQUEFACTION ANALYSIS

(Canadian Foundation Engineering Manual, 4E)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 24-15

Ground Surface Elev. = 87.2 m

Earthquake Magnitude, M = 6.5

Water Table Depth = 1.5 m

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	N_{60}	$(N_1)_{60}$	%Fine	CRR				CSR			FS_L
									CRR_1	K_σ	K_m	CRR	a_{max}/g	r_d	CSR	
0.0	Fill	18.0	0.0	0.0	0.0											
0.9	Organic Cl Si	16.0	14.7	0.0	14.7											
0.9	Si Cl	18.0	14.7	0.0	14.7											
4.5	Si Sa Till, loose to compact	20.0	86.7	29.4	57.3	8	9	15	0.14	1.00	1.44	0.20	0.36	0.97	0.34	0.59
4.8	Si Sa Till, loose to compact	20.0	91.4	31.7	59.7	8	9	15	0.14	1.00	1.44	0.20	0.36	0.96	0.35	0.58
5.0	Si Sa Till, loose to compact	20.0	96.1	34.0	62.0	8	9	15	0.14	1.00	1.44	0.20	0.36	0.96	0.35	0.57
5.2	Si Sa Till, loose to compact	20.0	100.7	36.3	64.4	8	9	15	0.14	1.00	1.44	0.20	0.36	0.96	0.35	0.56
5.5	Si Sa Till, loose to compact	20.0	105.4	38.6	66.8	8	9	15	0.13	1.00	1.44	0.19	0.36	0.96	0.35	0.54
5.7	Si Sa Till, loose to compact	20.0	110.1	40.9	69.2	8	9	15	0.13	1.00	1.44	0.19	0.36	0.96	0.36	0.53
5.9	Si Sa Till, loose to compact	20.0	114.7	43.2	71.6	8	9	15	0.13	1.00	1.44	0.19	0.36	0.95	0.36	0.52
5.9	Shale	21.0	114.7	43.2	71.6											
5.9	Shale	21.0	114.7	43.2	71.6											
5.9	Shale	21.0	114.7	43.2	71.6											

Project No. : OTT-22026647-A0

Prepared By : HW

Date : May, 2024

Checked By : SP

#N/A

LIQUEFACTION ANALYSIS
(Canadian Foundation Engineering Manual, 4E)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 24-15

Ground Surface Elev. = 87.2 m

Earthquake Magnitude, M = 6.5

Water Table Depth = 1.5 m

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	N_{60}	$(N_1)_{60}$	%Fine	CSR			Shear Wave Velocity		CRR	FS_L
									a_{max}/g	r_d	CSR	V_s (m/s)	V_{s1} (m/s)		
0.0	Fill	18.0	0.0	0.0	0.0										
0.9	Organic Cl Si	16.0	14.7	0.0	14.7										
0.9	Si Cl	18.0	14.7	0.0	14.7										
4.5	Si Sa Till, loose to compact	20.0	86.7	29.4	57.3	8	9	15	0.36	0.97	0.34	125	148	0.09	0.25
4.8	Si Sa Till, loose to compact	20.0	91.4	31.7	59.7	8	9	15	0.36	0.96	0.35	125	146	0.08	0.24
5.0	Si Sa Till, loose to compact	20.0	96.1	34.0	62.0	8	9	15	0.36	0.96	0.35	125	145	0.08	0.23
5.2	Si Sa Till, loose to compact	20.0	100.7	36.3	64.4	8	9	15	0.36	0.96	0.35	125	143	0.08	0.22
5.5	Si Sa Till, loose to compact	20.0	105.4	38.6	66.8	8	9	15	0.36	0.96	0.35	125	141	0.08	0.21
5.7	Si Sa Till, loose to compact	20.0	110.1	40.9	69.2	8	9	15	0.36	0.96	0.36	125	139	0.07	0.20
5.9	Si Sa Till, loose to compact	20.0	114.7	43.2	71.6	8	9	15	0.36	0.95	0.36	125	138	0.07	0.19
5.9	Shale	21.0	114.7	43.2	71.6										
5.9	Shale	21.0	114.7	43.2	71.6										
5.9	Shale	21.0	114.7	43.2	71.6										

Project No. : OTT-22026647-A0

Prepared By : HW

Date : May, 2024

Checked By : SP

#N/A

LIQUEFACTION ANALYSIS
(Canadian Foundation Engineering Manual, 4E)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 24-15

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	$(N_1)_{60}$	CSR	Liquefied Shear Strength						Post-Liquefaction Settlement		
								Ratio			Residual Strength					
								max.	aver.	min.	max. (kPa)	aver. (kPa)	min. (kPa)	ε	Δs (mm)	s (mm)
0.0	Fill	18.0	0.0	0.0	0.0											
0.9	Organic Cl Si	16.0	14.7	0.0	14.7											
0.9	Si Cl	18.0	14.7	0.0	14.7											
4.5	Si Sa Till, loose to compact	20.0	86.7	29.4	57.3	9	0.34	0.130	0.099	0.068	7.5	5.7	3.9			
4.8	Si Sa Till, loose to compact	20.0	91.4	31.7	59.7	9	0.35	0.130	0.099	0.068	7.8	5.9	4.1	3.9%	9.1	9.1
5.0	Si Sa Till, loose to compact	20.0	96.1	34.0	62.0	9	0.35	0.130	0.099	0.068	8.1	6.2	4.2	4.0%	9.3	18.4
5.2	Si Sa Till, loose to compact	20.0	100.7	36.3	64.4	9	0.35	0.130	0.099	0.068	8.4	6.4	4.4	4.0%	9.3	27.8
5.5	Si Sa Till, loose to compact	20.0	105.4	38.6	66.8	9	0.35	0.130	0.099	0.068	8.7	6.6	4.6	4.0%	9.3	37.1
5.7	Si Sa Till, loose to compact	20.0	110.1	40.9	69.2	9	0.36	0.130	0.099	0.068	9.0	6.9	4.7	4.0%	9.3	46.4
5.9	Si Sa Till, loose to compact	20.0	114.7	43.2	71.6	9	0.36	0.130	0.099	0.068	9.3	7.1	4.9	4.1%	9.6	56.0
5.9	Shale	21.0	114.7	43.2	71.6											
5.9	Shale	21.0	114.7	43.2	71.6											
5.9	Shale	21.0	114.7	43.2	71.6											

Total Post-Liquefaction Settlement **56 mm**

Overall Strain **4.0%**

Residual Strength **4 - 9 kPa**

Project No. : OTT-22026647-A0

Date : May, 2024

Prepared By : HW

Checked By : SP

#N/A

LIQUEFACTION ANALYSIS

(D.P. Coduto (1999) Geotechnical Engineering Principles and Practices)

Project Name : 1770 Heatherington Rd, Ottawa

Reference Borehole : BH 24-15

Ground Surface Elev. = 87.2 m

Water Table Depth = 1.5 m

Earthquake Magnitude, M = 6.5

Distance to fault trace, d = 2.0 km

Depth z (m)	Soil Classification	γ (kN/m^3)	σ_v (kPa)	μ (kPa)	σ_v' (kPa)	N_{60}	$(N_1)_{60}$	%Fine	CRR			CSR				FS_L
									CRR_1 M=7.5	ψ M=6.5	CRR	a_{max}/g in rock	a_{max}/g in soil	r_d	CSR	
0.0	Fill	18.0	0.0	0.0	0.0											
0.9	Organic Cl Si	16.0	14.7	0.0	14.7											
0.9	Si Cl	18.0	14.7	0.0	14.7											
4.5	Si Sa Till, loose to compact	20.0	86.7	29.4	57.3	8	11	15	0.16	1.18	0.19	0.76	0.37	0.97	0.35	0.54
4.8	Si Sa Till, loose to compact	20.0	91.4	31.7	59.7	8	10	15	0.16	1.18	0.18	0.76	0.37	0.96	0.35	0.52
5.0	Si Sa Till, loose to compact	20.0	96.1	34.0	62.0	8	10	15	0.16	1.18	0.18	0.76	0.37	0.96	0.36	0.51
5.2	Si Sa Till, loose to compact	20.0	100.7	36.3	64.4	8	10	15	0.16	1.18	0.18	0.76	0.37	0.96	0.36	0.51
5.5	Si Sa Till, loose to compact	20.0	105.4	38.6	66.8	8	10	15	0.16	1.18	0.18	0.76	0.37	0.96	0.36	0.50
5.7	Si Sa Till, loose to compact	20.0	110.1	40.9	69.2	8	10	15	0.16	1.18	0.18	0.76	0.37	0.96	0.37	0.50
5.9	Si Sa Till, loose to compact	20.0	114.7	43.2	71.6	8	9	15	0.15	1.18	0.18	0.76	0.37	0.95	0.37	0.48
5.9	Shale	21.0	114.7	43.2	71.6											
5.9	Shale	21.0	114.7	43.2	71.6											
5.9	Shale	21.0	114.7	43.2	71.6											

Project No. : OTT-22026647-A0

Date : May, 2024

Prepared By : HW

Checked By : SP

#N/A

Appendix G – Laboratory Certificate of Analysis Report

AGAT Laboratories

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: EXP SERVICES INC
2650 QUEENSVIEW DRIVE, UNIT 100
OTTAWA, ON K2B8H6
(613) 688-1899
ATTENTION TO: Matthew Zammit
PROJECT: OTT-22026647-A0
AGAT WORK ORDER: 23Z105906
SOIL ANALYSIS REVIEWED BY: Nivine Basily, Inorganic Team Lead
DATE REPORTED: Dec 28, 2023
PAGES (INCLUDING COVER): 5
VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

Notes

Disclaimer:

- *All work conducted herein has been done using accepted standard protocols, and generally accepted practices and methods. AGAT test methods may incorporate modifications from the specified reference methods to improve performance.*
- *All samples will be disposed of within 30 days after receipt unless a Long Term Storage Agreement is signed and returned. Some specialty analysis may be exempt, please contact your Client Project Manager for details.*
- *AGAT's liability in connection with any delay, performance or non-performance of these services is only to the Client and does not extend to any other third party. Unless expressly agreed otherwise in writing, AGAT's liability is limited to the actual cost of the specific analysis or analyses included in the services.*
- *This Certificate shall not be reproduced except in full, without the written approval of the laboratory.*
- *The test results reported herewith relate only to the samples as received by the laboratory.*
- *Application of guidelines is provided "as is" without warranty of any kind, either expressed or implied, including, but not limited to, warranties of merchantability, fitness for a particular purpose, or non-infringement. AGAT assumes no responsibility for any errors or omissions in the guidelines contained in this document.*
- *All reportable information as specified by ISO/IEC 17025:2017 is available from AGAT Laboratories upon request.*
- *For environmental samples in the Province of Quebec: The analysis is performed on and results apply to samples as received. A temperature above 6°C upon receipt, as indicated in the Sample Reception Notification (SRN), could indicate the integrity of the samples has been compromised if the delay between sampling and submission to the laboratory could not be minimized.*

AGAT Laboratories

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Certificate of Analysis

AGAT WORK ORDER: 23Z105906

PROJECT: OTT-22026647-A0

CLIENT NAME: EXP SERVICES INC

ATTENTION TO: Matthew Zammit

SAMPLING SITE:1770 Heatherington Road, Ottawa

SAMPLED BY:EXP

Inorganic Chemistry (Soil)

DATE RECEIVED: 2023-12-19 **DATE REPORTED: 2023-12-28**

				BH 23-2 SS5	BH 23-4 SS4	BH 23-8 SS5
		SAMPLE DESCRIPTION:		10'-12'	10'-12'	12.5'-14.5'
		SAMPLE TYPE:		Soil	Soil	Soil
		DATE SAMPLED:		2023-12-01	2023-12-01	2023-11-21
Parameter	Unit	G / S	RDL	5557582	5557585	5557586
Chloride (2:1)	µg/g		2	39	256	1100
Sulphate (2:1)	µg/g		2	167	134	205
pH (2:1)	pH Units		NA	8.33	7.97	7.95
Resistivity (2:1) (Calculated)	ohm.cm		1	2430	1070	296

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

5557582-5557586 pH, Chloride and Sulphate were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil). Resistivity is a calculated parameter.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:

AGAT Laboratories

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Quality Assurance

CLIENT NAME: EXP SERVICES INC

AGAT WORK ORDER: 23Z105906

PROJECT: OTT-22026647-A0

ATTENTION TO: Matthew Zammit

SAMPLING SITE:1770 Heatherington Road, Ottawa

SAMPLED BY:EXP

Soil Analysis

RPT Date: Dec 28, 2023			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Inorganic Chemistry (Soil)															
Chloride (2:1)	5557582	5557582	39	38	1.4%	< 2	96%	70%	130%	95%	80%	120%	95%	70%	130%
Sulphate (2:1)	5557582	5557582	167	165	1.1%	< 2	96%	70%	130%	96%	80%	120%	102%	70%	130%
pH (2:1)	5557582	5557582	8.33	8.31	0.3%	NA	95%	80%	120%						

Comments: NA signifies Not Applicable.
pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.

Duplicate NA: results are under 5X the RDL and will not be calculated.

Certified By:

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Method Summary

CLIENT NAME: EXP SERVICES INC

AGAT WORK ORDER: 23Z105906

PROJECT: OTT-22026647-A0

ATTENTION TO: Matthew Zammit

SAMPLING SITE:1770 Heatherington Road, Ottawa

SAMPLED BY:EXP

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Chloride (2:1)	INOR-93-6004	modified from SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	modified from SM 4110 B	ION CHROMATOGRAPH
pH (2:1)	INOR 93-6031	modified from EPA 9045D and MCKEAGUE 3.11	PH METER
Resistivity (2:1) (Calculated)	INOR-93-6036	McKeague 4.12, SM 2510 B,SSA #5 Part 3	CALCULATION

AGAT Laboratories

Have feedback? Scan here for a quick survey!

5835 Coopers Avenue
Mississauga, Ontario L4Z 1Y2
Ph: 905.712.5100 Fax: 905.712.5122
webearth.agatlabs.com

Chain of Custody Record

If this is a Drinking Water sample, please use Drinking Water Chain of Custody Form (potable water consumed by humans)

Laboratory Use Only

Work Order #: 2321059006

Cooler Quantity: n/a - no ice packs

Arrival Temperatures: 23.5 | 23.5 | 23.7 / 4.2 | 4.5 | 4.0

Custody Seal Intact: ☐ Yes ☐ No ☐ N/A

Notes: bagged ice

Report Information:

Company: EXP Services Inc
Contact: Matthew Zammit
Address: 2650 Queensview Drive Unit 100, Ottawa, ON, K2B 8H6
Phone: 613-688-1891 Fax:
Reports to be sent to:
1. Email: matthew.zammit@exp.com
2. Email: jeff.macmillan@exp.com

Regulatory Requirements:

(Please check all applicable boxes)

☐ Regulation 153/04
Table (Indicate One) ☐ Ind/Com ☐ Res/Park ☐ Agriculture
Soil Texture (Check One) ☐ Coarse ☐ Fine

☐ Regulation 406
Table (Indicate One)

☐ Regulation 558

☐ CCME

☐ Sewer Use ☐ Sanitary ☐ Storm
(Region)

☐ Prov. Water Quality Objectives (PWQO)

☐ Other
(Indicate One)

Is this submission for a **Record of Site Condition?** ☐ Yes ☐ No

Report Guideline on *Certificate of Analysis* ☐ Yes ☐ No

Turnaround Time (TAT) Required:

Regular TAT ☑ 5 to 7 Business Days

Rush TAT (Rush Surcharges Apply)

☐ 3 Business Days ☐ 2 Business Days ☐ Next Business Day

OR Date Required (Rush Surcharges May Apply):

Please provide prior notification for rush TAT
**TAT is exclusive of weekends and statutory holidays*

For 'Same Day' analysis, please contact your AGAT CPM

Project Information:

Project: OTT-22026647-A0
Site Location: 1770 Heatherington Road, Ottawa
Sampled By: EXP
AGAT Quote #: PO:
Please note: If quotation number is not provided, client will be billed full price for analysis.

Invoice Information:

Bill To Same: Yes ☑ No ☐

Company:
Contact:
Address:
Email:

Sample Matrix Legend

GW	Ground Water
O	Oil
P	Paint
S	Soil
SD	Sediment
SW	Surface Water

Sample Identification	Date Sampled	Time Sampled	# of Containers	Sample Matrix	Comments/ Special Instructions	Field Filtered - Metals, Hg, CrVI, DOC (Y/N)	O. Reg 153: Metals & Inorganics	O. Reg 153: Metals - ☐ CrVI, ☐ Hg, ☐ HWSB	O. Reg 153: BTEX, F1-F4 PHCs	VOC	PAHs	PCBs	PCBs: Aroclors ☐	O. Reg 558: Landfill Disposal Characterization TCLP: ☐ M&I ☐ VOCs ☐ ABNs ☐ B(a)P ☐ PCBs	O. Reg 406: Regulation 406 SPLP Rainwater Leach SPLP: ☐ Metals ☐ VOCs ☐ SVOCs	O. Reg 406: Regulation 406 Characterization Package pH, ICPMS Metals, BTEX, F1-F4	Corrosivity: ☐ Moisture ☐ Sulphide	pH	Sulphate	Chloride	Resistivity			Potentially Hazardous or High Concentration (Y/N)
1. BH 23-2 SS5 10'-12'	Dec. 1	AM PM	1	S														☑	☑	☑	☑			
2. BH 23-4 SS4 10'-12'	Dec. 1	AM PM	1	S														☑	☑	☑	☑			
3. BH 23-8 SS5 12.5'-14.5'	Nov. 21	AM PM	1	S														☑	☑	☑	☑			
4.		AM PM																						
5.		AM PM																						
6.		AM PM																						
7.		AM PM																						
8.		AM PM																						
9.		AM PM																						
10.		AM PM																						
11.		AM PM																						

Samples Relinquished By (Print Name and Sign):	Date	Time	Samples Received By (Print Name and Sign):	Date	Time
Jeff MacMillan	Dec.18, 2023		C Griffith	12/19/23	08h15
CC to Dave	12/19/23	19h20	D	20	8:35

Page 1 of 1

No:

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